900
Offshore/ Continental Shelf

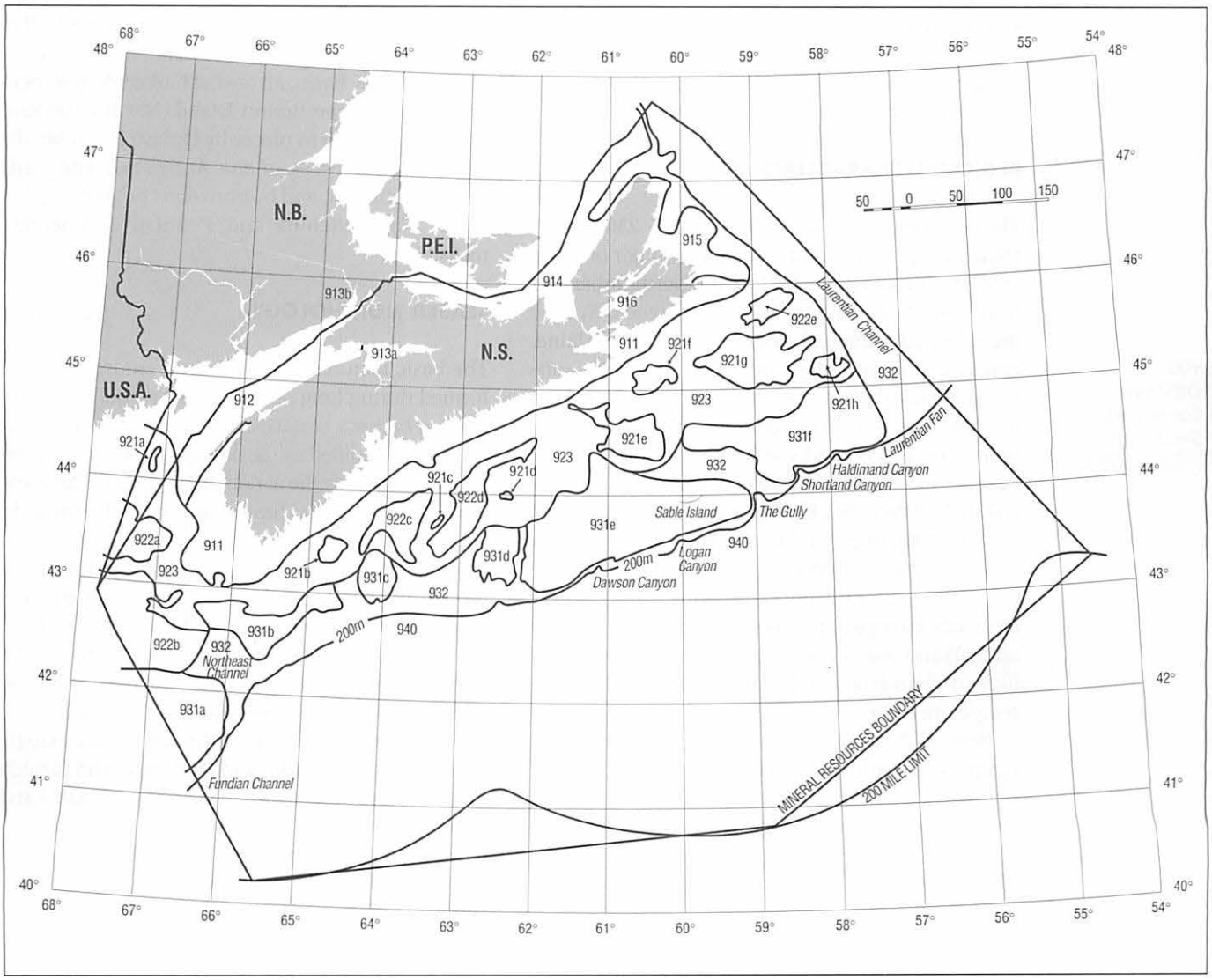

Figure 30: Region 900, Offshore/Continental Shelf, and its component Districts, Units, and sub-Units.

900 OFFSHORE/CONTINENTAL SHELF

The following physiographic features are the basis for the division of the Districts of Region 900:

- District 910, Inner Shelf, is a zone of gradually sloping bottom adjacent to shore and extending to depths of about 110 metres in all areas
- District 920, Middle Shelf, is a zone of fishing banks and deep basins in the mid-portions of the continental shelf and includes the Scotian Shelf and the Gulf of Maine
- District 930, Outer Shelf, is a zone of large offshore banks and intervening channels and saddles on the outer edge of the continental shelf
- District 940, Scotian Slope, is the deep-water area beyond the shelf break and continental slope extending to Canada/Nova Scotia jurisdictional limits

REGIONAL CHARACTERISTICS

The continental shelf extends from 125–230 km offshore to depths of about 200 metres. Major offshore areas that make up the shelf are the Northumberland Strait, southeastern Gulf of St. Lawrence, Sydney Bight, Scotian Shelf, Georges Bank, Gulf of Maine, and Bay of Fundy. The landscape is that of a submerged coastal plain, and the structure reflects long periods of terrestrial erosion, the passage of continental ice sheets, and the influence of the ocean. Features include basins up to 280 m deep on the central shelf; fishing banks; channels; and Sable Island (District 890), on Sable Island Bank, extending 26 m above sea level. Waters from the Gulf of St. Lawrence and from further offshore (the slope water) mainly influence biological processes on the shelf; and the animals and plants, and seasonal cycles of productivity and abundance, follow patterns typical of cool temperate regions.

Beyond the shelf break (200 m) the bottom slopes steeply to a depth of 2,000 metres, reaching a maximum of 5,000 metres at the edge of the Region. The area experiences full oceanic conditions.

GEOLOGY

Various geological or bedrock provinces are represented on the continental shelf (see T3.5). Inshore, the bedrock is usually a seaward extension of rock formations on the adjacent land. Areas of complex geology may have different subtidal bedrock than on the coast. Patterns and variations of bedrock geology are not as easily identified in the offshore but are probably as varied as on land.

Four major geological or bedrock units are represented: (1) the Acadian Basin, an area of Triassic rocks in the Bay of Fundy and northern Gulf of Maine, (2) terrestrial bedrock extending to 25 km offshore along the Atlantic coast of Nova Scotia and into basins on the south side of the Gulf of Maine, (3) an outer area comprising the Middle and Outer Scotian Shelf, consisting of Jurassic, Cretaceous, and Tertiary rocks and including Georges Bank, the outer Gulf of Maine, and the outer part of the Laurentian Channel, and (4) Sydney Basin, an area of Carboniferous rocks northeast of Cape Breton Island. Northumberland Strait is underlain in places by Ordovician to Middle Carboniferous rocks of the Antigonish and Cape Breton highlands, and by horizontal or gently folded Upper Carboniferous and Permian sedimentary rocks.

SEABED MORPHOLOGY

The basic features of the marine "landscape" were formed during long periods of terrestrial erosion of ancient bedrock surfaces. This topography was subsequently modified by the passage of glaciers and, on a smaller scale, by the action of the sea. The large features (e.g., banks and basins) are not unlike uplands, peneplains, and valley systems on the modern mainland surface, sharing their elevation and extent, although the continental shelf lacks prominent geological features like those found on land (e.g., Cape Breton highlands, North Mountain). Where ancient drainage systems reached the edge of the continental shelf, dramatic, steep-sided submarine valleys reach down the continental slope. Glacial features create more localized variations in landscape and include moraines and other features, such as pockmarks and iceberg scours (see T3.4). The surface sediment patterns on the continental shelf result from the action of the ocean and its interaction with retreating Holocene glaciers. The finest surface features are caused by waves and currents, and include sand ridges, waves, and ripples. Sable Island (Region 890)

is a unique offshore feature derived from glacial material on top of early bedrock features.

CLIMATE

The climate of the Offshore/Continental Shelf Region follows the general pattern found on land but does not show the same degree of local variation. In addition to atmospheric factors, the temperature of the ocean and distance from land influence climate at sea. The ocean can hold heat and tends to moderate the temperature of the air above it.

In general, wind speeds are higher over the sea than over land because of reduced wind resistance. However, offshore winds are reduced within a few kilometres of the shore because of the shielding effect of the land. Further out to sea, wind is virtually unhindered and assumes a speed which more closely resembles the velocity of the wind tens of metres above the surface.

The temperatures of water masses influence air temperatures, significantly in some cases. In early spring the water is cold and cools the air above it, frequently forming fog. As the season progresses, the surface waters are heated by sunlight and grow gradually warmer. This rise is punctuated by periods when storms bring cold water to the surface and bring temporary declines in temperature. The annual peak water temperature occurs in the fall in the Atlantic (Unit 911) and the Outer Bay of Fundy (Unit 912), but warmer temperatures are observed in late summer in the Northumberland Strait (Unit 914), Minas Basin (sub-Unit 913a), and shallow coastal bays and inlets (District 460) where water is shallower and less influenced by colder, deeper water. The resulting warmer water temperatures make these areas popular for tourists.

Areas where warm and cold water masses meet are also marked by abrupt changes in air temperature. Just beyond the outer edge of the continental shelf, a warmer water mass (slope water) meets the shelf water and results in a sudden temperature change for ships passing across the boundary. Further offshore, the edge of the Gulf Stream heralds a sudden jump in temperatures to near tropical conditions. Even in winter, sailors can work comfortably here in shirt sleeves. In both cases, fog frequently occurs along the boundaries as warmer humid air flows over cooler water and condensation (fog) develops.

The waters of the Outer Bay of Fundy seldom have a chance to warm at the surface because of the significant mixing caused by tidal movements. Consequently, the water is cool most of the year. Just outside the Bay of Fundy, however, the water is more stable and can warm up more. The contrast in the temperatures of these water masses is one of the causes of the frequent fogs in southwest Nova Scotia, particularly near Yarmouth.

OCEANOGRAPHY

Tides, winds, buoyancy, and remote forcing are important oceanographic factors on the continental shelf (see T6.1). The large ocean currents include the extension of the Gaspé Current in Northumberland Strait, and the Nova Scotia Current along the continental shelf. The Gulf Stream comes closest to the Canadian continental shelf off East Georges Bank (sub-Unit 931a). Other oceanographic features include coastal upwelling, estuarine circulation, tidal fronts, tidal gyres, shelf-break fronts, and warm-core rings.

Temperature and salinity are important components of oceanic climate and influence biological productivity. In February, upper layer temperatures in some areas are at or near freezing, while temperatures on the South Shore of Nova Scotia and in the Bay of Fundy are considerably warmer. August temperatures are highest in Northumberland Strait and become cooler southwestwards from Cape Breton along the Atlantic Coast (Region 800). At the sea surface on the Scotian Shelf, temperature and salinity increase as one moves southeastwards from land.

SEDIMENTS

Most sediments on the continental shelf originated as glacial deposits. Glacial till was deposited in some places, while silt from glacial meltwater extended widely. Following glaciation, glacial till on the shallower parts was exposed to the action of the ocean, which washed and sorted it and spread a layer of clays to the deep basins and a fringe of sand to the offshore banks, resulting in the general pattern observed today. Unlike the land, the ocean bottom has not been modified significantly by the growth of plants and soil formation, and in many cases is being continually altered, at least in surface layers, by ocean processes.

The tops of banks and shallow coastal areas throughout the Region are generally sandy to gravelly in character and occasionally have large boulders like the glacial erratics found on land, thus making bad trawling ground. Below a depth of 100–120 m, the sediments have more sand and finer material but still contain boulders and gravel. These deeper sediments were never reworked by rising sea levels at the end of the last glaciation and consequently have

retained more fine sediment components. In contrast, near the Atlantic coast of Nova Scotia and up to 25 km offshore, the bottom is rough and rocky—part of the bedrock of the coastal land mass. The relatively steep slope, in combination with rising sea levels, led to the scouring of most of the surface sediment, leaving only bedrock.

In the deeper basins, clays occur, because water motion is low enough to permit fine particles to settle. Deep channels and submarine canyons frequently have strong currents and usually contain coarse sediments. The bottom of the continental slope has thick surficial sediments of clay and sand.

PLANTS

Beds of kelp and other marine algae grow on the seabed close to shore, and microscopic phytoplankton occur both nearshore and in most other waters. Most anchored marine plants can occur only to a depth of about 30 m and generally fall into two types: those attached to rocks and those in soft bottom. The main attached species of the Nova Scotia coast are the kelps and rockweeds, but more than 300 species of seaweed occur around Nova Scotia coasts.

Marine seaweed growth is most abundant on exposed rocky shores typical of the Atlantic coast, where there are sites for attachment and adequate water movements to supply nutrients. Seaweeds generally grow less and their shapes change in sheltered environments. In areas with ice cover through part of the year, profuse algal growth can develop only beneath the depth of winter ice scour, even on a suitable substrate. These areas—the Northumberland Strait (Unit 914), Inner Bay of Fundy (Unit 913), and Bras d'Or Lake (Unit 916)—have a characteristic intertidal zone scraped clean of algae every year but upon which a carpet of algae can develop seasonally. Irish Moss develops in the subtidal zone beneath the ice in western and northern P.E.I.

Particularly in the Northumberland Strait but also in protected inlets and bays throughout Nova Scotia, soft bottoms, usually just below tide level, are populated by Eelgrass. This flowering plant grows the world over and is important in marine food chains. Eelgrass beds support a diverse invertebrate fauna as well as the young stages of a variety of fish and shellfish species.

Phytoplankton, notably diatom growth, occurs throughout the offshore and creates the main food source for planktonic animals and bottom-dwelling filter feeders. It eventually reaches and supports the extensive offshore fisheries resource. Areas of enhanced phytoplankton growth occur where ocean conditions bring nutrients to the surface, such as along the Atlantic coast, off southwest Nova Scotia, on the northern margin of Georges Bank (upwellings), and in a band stretching along the outer edge of the Scotian Shelf, where shelf and slope water meet and nutrients come to the surface. Water column activity peaks from spring to summer.

Plants in the Nova Scotia offshore are generally typical of the boreal cold-water species which occur throughout much of the North Atlantic. Plant production of both seaweeds and phytoplankton in these areas is typically among the highest in the world. Occasional warmer-water species occur, often introduced by shipping. A suite of warm-water algae occurs in the Gulf of St. Lawrence in estuaries and lagoons where water temperatures are higher.

ANIMALS

Oceanic food chains are based on phytoplankton primary production. Most organisms in the ocean feed on phytoplankton, if only in their juvenile stages. Microscopic phytoplankton is consumed directly by grazing vertebrates, invertebrates and by suspension feeders such as mussels, scallops and oysters. Seaweeds also form the basis for food chains involving grazers such as sea urchins, or a wide variety of detritivores, upon death. Invertebrate communities are much more in evidence in these ecosystems, within the water column, on substrate surfaces as well as within the sediments.

The major commercial fish species are groundfish that live on or near the bottom and include cod, haddock, pollock, halibut, and various species of flatfish. These feed on seabed invertebrates as adults but consume zooplankton as they develop from eggs and larvae.

Principal pelagic fish species on the continental shelf (herring, mackerel, Bluefin Tuna, capelin, and some smaller species) feed on zooplankton or smaller fish all their lives (herring can use gill structures to filter the water). Deep water beyond the shelf break has an oceanic fauna with characteristic zooplankton and mesopelagic fish, cephalopods, and crustaceans. Baleen whales such as the Humpback feed on zooplankton, and toothed whales, including the endangered Northern Right Whale, another common Nova Scotia species, feed on fish and squid. Nova Scotia has a summer population of rare Bottlenose Whales near Misaine Bank that feeds on squid concentrated there.

Seabirds include common species associated with land and coastal areas (Herring and Black Back gulls, Great and Double-crested cormorants) and truly oceangoing birds such as shearwaters, terns, jaegers, phalaropes, and Storm-petrels, which migrate seasonally into Nova Scotia waters. Nesting colonies of gannets, puffins, petrels, and kittiwakes use offshore waters as a food source, with certain species sometimes flying daily to outer parts of the continental shelf. Waters off Nova Scotia are resting places for more northerly species and for overwintering waterfowl such as geese and seaducks.

CULTURAL ENVIRONMENT

For thousands of years the waters off Nova Scotia have been important for coastal transportation and their marine resources have been used by aboriginal peoples and later immigrants. The abundance of marine fisheries was noted by early European explorers. Excellent harbours provided sites for European settlement, commerce, and strategic naval and military bases (e.g., Louisbourg 1712 and Halifax 1749). The wide range of seaweed, shellfish, groundfish, pelagic fish, and marine mammal resources are now regulated to compensate for overuse and the effects of coastal pollution. Closure of the ground fisheries in 1992 had a severe economic impact. Hydrocarbon (oil and gas) and other mineral resources of the seabed are under development. Several marine locations have been used as dumping areas, particularly for munitions, and many submarine cables have been laid throughout the Region.

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Associated Topics
T2.7 Offshore Geology, T3.5 Offshore Bottom Characteristics, T5.1 The Dynamics of Nova Scotia's Climate, T5.2 Nova Scotia's Climate, T6.1 Ocean Currents, T6.2 Oceanic Environments, T6.3 Coastal Aquatic Environments, T10.9 Algae, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.3 Geology and Resources, T12.6 The Ocean and Resources.

Associated Habitats
H1.1 Offshore Open Water, H1.2 Offshore Benthic, H2 Coastal.

910 INNER SHELF

The Inner Shelf District comprises a large geographic area extending from the Northumberland Strait to the Bay of Fundy. The District has been divided into the following Units:

911 Atlantic
912 Outer Bay of Fundy
913 Inner Bay of Fundy
914 Northumberland Strait
915 Sydney Bight
916 Bras d'Or Lake

GEOLOGY AND SEABED MORPHOLOGY

The Inner Shelf District borders the landmass of Nova Scotia, extending seaward from the coastline to a depth of 100–120 m. In most places the bottom gradually slopes offshore and is generally covered by reworked glacial till containing sand, gravel, and larger material, including boulders. Exposed bedrock occurs in places. Topography follows the ancient bedrock surface, but in some cases ancient features eroded in the bedrock (e.g., the valley of the ancient Sackville River on the continental shelf) have been infilled by later deposits. Inner Shelf banks occur in several areas (German Bank and Lurcher Shoals off southwestern Nova Scotia; St. Anns Bank in Sydney Bight).

On the Atlantic Coast (Region 800), the Inner Shelf is part of the Atlantic Uplands, a geomorphic division of the Appalachian Region. Here the bottom slopes steadily offshore to a distance of about 25 km and has had much of its glacial deposits removed by the sea level advance, leaving significant exposures of bedrock.

In the Bay of Fundy and eastern Gulf of Maine, the Inner Shelf falls in the Fundian Lowlands, a part of the Carboniferous-Triassic lowlands of the Appalachian Region. The bottom contours largely follow the coastline and reflect its origin as a former drainage system originating in the Minas Basin–Truro area.

In Sydney Bight the Inner Shelf is largely underlain by Carboniferous rocks of the Sydney Basin. The topography is relatively flat and slopes gradually out to sea, forming an Inner Shelf bank. Bedrock exposures occur throughout this area.

West of Cape Breton in the southeastern Gulf of St. Lawrence, Ordovician to Middle Carboniferous rocks of the Antigonish and Cape Breton highlands extend under St. Georges Bay to approximately 16 km offshore. The west and central parts of the Northumberland Strait are underlain by horizontal or gently folded Upper Carboniferous and Permian sedimentary rocks.

SEDIMENTS

Coarse sand and gravel mixtures predominate in the Inner Shelf District, though there are significant local variations. Often the sediments vary locally in composition based on the kinds of material derived from local erosion and their degree of exposure to waves and currents. Depressions in the Inner Shelf, as found in Chedabucto Bay and deeper areas of Northumberland Strait, have clay deposits.

PLANTS

Seaweeds grow in a band extending down to 30 m along the coast. Growth is patchy, reflecting the availability of suitable rock substrate and other factors, such as the activity of grazing animals and exposure to sea ice. Stunted and encrusting marine algae can be found attached to rocks throughout most of the Inner Shelf, but growth is most dense near mean low water. Kelps are commonly the most conspicuous species below mean low water along exposed coasts. Rockweed frequently occurs in the intertidal zone in coastal areas. Introduced species occasionally occur. Dead Man's Fingers has been found in dense stands in Prospect and Mahone bays (Unit 911); this species is believed to have been introduced from Japan to Europe, to New England, and then to Nova Scotia.

Algal cover in the Northumberland Strait and the Inner Bay of Fundy tends to be less dense in exposed areas because of the abrasive action of ice. The intertidal zone is scraped clean of algae every year to a depth of several metres below low tide marks and results in the development of a "lawn" of short developing plants in the scraped areas. Ice also lifts off large patches of Eelgrass in some areas, creating many underwater "potholes" and bare areas.

Phytoplankton productivity is high as a result of oceanographic processes which enhance nutrient supply in the coastal zone. Algal "blooms" of dinoflagellates and diatoms occur at peak productive times of the year—the spring and early fall. Dense

concentrations of dinoflagellates can create luminescent displays in coastal inlets and add a glow to the wake of passing ships, and they can also cause shellfish poisoning.

ANIMALS

Most of the major offshore marine animal groups can be found in the Inner Shelf. Species that rely on filtering phytoplankton from the water, and estuarine species concentrate in this District. Suspension feeders include mussels, oysters, and scallops on appropriate substrates.

Many species of fish and invertebrates such as lobster live on the Inner Shelf because of its favourable temperatures and feeding conditions. The young of many fish species find food and protection in the algal beds and rocky surface features. Many fish species live in coastal waters and nearby freshwater environments during part of the year.

Migratory fish species such as herring and mackerel move seasonally into these areas; herring frequently spawn in shallows and on some offshore banks, attaching their eggs to the seabed. Large schools of adult Mackerel approach the Atlantic coast in late May and leave again in the fall, accompanied by young-of-the-year. Coastal populations of Sand Lance and Atlantic Silverside shoal in nearshore waters. Cod move inshore as the water warms in the summer. The shelter provided by algal beds, rocks, and boulders—and an ample food supply—provide ideal habitat for lobster. Large clam species, particularly the Ocean Quahog, occur in the sediments.

Seals and whales use the Inner Shelf as both a seasonal and year-round food source. Whales, including the Humpback and Northern Right, move into the area from more southerly areas to feed on summer populations of plankton and fish. Many North Atlantic whale species also move through Nova Scotia inshore and offshore waters en route to summering areas further to the north. The small Harbour Porpoise is characteristic of the coastal zone.

The Inner Shelf supports Harbour and Grey seals which feed on fish and invertebrates in the nearshore zone for at least part of the year. Grey Seals from most Atlantic coastal areas migrate to Sable Island, where they give birth in the spring.

The Inner Shelf is also home to a host of North Atlantic seabirds, many of which nest on shore and feed on the rich animal life just offshore; included are gulls, terns, cormorants, and Storm-petrels. Isolated colonies of seabirds such as Atlantic Puffin, Razorbill, Black-legged Kittiwake, and gannets also occur along the coasts.

OCEANOGRAPHY

Oceanographic features of the Inner Shelf include coastal upwelling, tidal fronts, tidal gyres, and a residual drift current eastwards through Northumberland Strait, around Cape Breton Island, and southwestwards to Cape Sable. Waters in the Inner Shelf tend to have higher turbidity owing to suspended sediments and increased phytoplankton growth at certain times of the year.

In general, the seasonal range of average water temperatures is higher in the upper layers than in the deeper layers, and is higher off Cape Breton than off Yarmouth. This reflects the reduced stratification and increased tidal mixing off Yarmouth.

CULTURAL ENVIRONMENT

The Inner Shelf District provides the most accessible marine resources for Nova Scotians, and several fisheries of high economic importance are found here. The relative importance of fisheries varies around the coast depending upon species, seasons, and environmental factors. Included are seaweeds, molluscs (clams, oysters, mussels, scallops, periwinkles, and squid), crustaceans (crabs, lobsters, and shrimp), demersal (bottom) fish (cod, pollock, and flounders), and pelagic fish (mackerel, herring, and tuna). Coastal waters offer the potential for the culture of various other species that can thrive on the phytoplankton found there. The inshore fishery for lobster occurs exclusively in this District. Anadromous fish that enter rivers and estuaries (e.g., Gaspereau and Atlantic Salmon) are also important. A wide range of gear, techniques, and vessels are used in these fisheries and often have local variations. The coast is divided into management districts, each of which has particular regulations regarding season, catch limit, and gear to be used. These resources have been greatly affected in recent years by pollution and sediment runoff from activities on land, red tides, and overexploitation. Aquaculture, particularly for mussels and salmonids, is becoming important. Other uses of the District include mining of placer deposits for sand and gravel, coastal recreation, marine transportation, and communications (submarine cables).

Associated Topics
T2.4 The Carboniferous Basin, T2.7 Offshore Geology, T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Ocean Environments, T10.9 Algae, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.3 Geology and Resources, T12.11 Animals and Resources.

Associated Habitats
H1 Offshore, H2 Coastal.

911 ATLANTIC

GEOLOGY AND SEABED MORPHOLOGY

The Atlantic Unit extends from Scatarie Bank off eastern Cape Breton Island to Brier Island on the west coast of Nova Scotia and includes German Bank off southwestern Nova Scotia. It is underlain by coastal extensions of Meguma bedrock, part of the Atlantic Uplands formation, and the surface is a combination of sandy/gravelly till, larger rocks and boulders, and exposed bedrock ledges. Most of the Atlantic Unit occurs on the Scotian Shelf, and bedrock slopes gradually offshore for 25 km to depths of approximately 110 m. There are significant surficial features, including gravel waves, bedrock folding, drumlins, and small glacial moraines. An extensive field of sand waves occurs on German Bank (50–100 m long). Most of the exposed coastline is rocky or in sand beaches but contains numerous protected bays and inlets, in many of which finer substrates occur.

SEDIMENTS

Surface sediments are thin and represent the remnants of glacial till which was extensively modified and removed during the recent advance of the sea. What remains of the glacial deposits is coarse gravel and sands (Sable Island Sand and Gravel) confined to depressions on the bedrock surface. The bedrock contains eroded valleys filled with glacial till. These extend from shore at the mouths of many major rivers that once flowed out onto the exposed shelf. Nearshore areas can have a variety of sediments as a result of local formation. A few localized depressions such as Chedabucto Bay contain pockets of clay.

OCEANOGRAPHY

The Unit is exposed to the Atlantic Ocean and, for the most part, the influence of the coastal Nova Scotia Current. Water movement shows a predominant drift southwestwards (the Nova Scotia Current). Coastal upwelling is driven in most of the District by southwesterly summer winds; however, off Cape Sable it is apparently driven by alongshore density variations maintained by tidal mixing (see T6.1).

Conditions in the western portion overlap those in the Bay of Fundy, possibly because of cooler ocean temperatures associated with upwelling induced by tides, but this part of the District differs from the Bay of Fundy by having a reduced tidal regime.

Surface waters are relatively fresh and warm. Underneath is a cold, more saline intermediate layer, and near the bottom a slightly warmer yet more saline layer with a larger slope water component.

PLANTS

The Atlantic Unit has some of the most significant seaweed growth and productivity in the province owing to the availability of suitable rocky bottom and adequate wave energy. Sheltered bays and estuaries have significant Eelgrass beds and tidal marshes.

Seaweeds occur in shallow water near shore, and phytoplankton is important throughout the Unit. The dominant species of kelp are *Laminaria longicruris, L. digitata,* and *Alaria esculenta* in the shallow subtidal; and *Agarum cribrosum* in deeper waters. Encrusting coralline algae cover rock surfaces in the shallower parts. Eelgrass grows in soft substrates in sheltered inlets along the coast.

ANIMALS

Similar species of lower animals (arctic-boreal in exposed areas and Virginian in sheltered situations) can be found throughout the Unit, varying according to local distributions of substrates and plants. The distribution of fish, birds, and marine mammals is more complex, reflecting long-established movement patterns and stock distributions. The spawning, summer, and larval distributions of herring coincide with the upwelling zones in southwestern Nova Scotia. Inshore concentrations of Atlantic Halibut are known off Cape Sable Island.

Bottom invertebrate communities typically include the Horse Mussel; sea cucumbers *Cucumaria frondosa* and *Psolus fabricii*; a sea star *Asterias vulgaris*; the amphipods *Corophium bonelli, Ischyrocerus anguipes, Jassa falcata,* and *Caprella* spp.; the barnacles *Balanus crenatus* and *B. hameri*; the crabs *Cancer borealis* and *C. irroratus*; and lobsters, scallops, quahogs, and sea urchins.

Several species of seabirds occur in offshore waters and Leach's Storm-petrel breeds on coastal islands chiefly in this Unit. Grey and Harbour seals fre-

quent coastal waters, and the small Harbour Porpoise is sparsely distributed along the coast. Several species of whale, including the Humpback, Fin, Minke, Northern Right, Pilot and Sei Whales, move through coastal waters and can be seen near the coast, though significant feeding areas are found only at the mouth of the Bay of Fundy.

Common Eider form large summer moulting concentrations offshore in the Port Mouton to Port l'Hebert area of the South Shore. Dense concentrations of Canada Geese overwinter in inlets in the above area and in the Musquodoboit to Cole Harbour area of the Eastern Shore, feeding on Eelgrass beds there.

CULTURAL ENVIRONMENT

The Atlantic Unit contains valuable resources of seaweed, lobster, herring, and mackerel. These tend to be most abundant in the southwest, but herring are important in Chedabucto Bay during the winter. Many communities have fleets of fishing vessels that make trips to Middle and Outer Shelf Districts 920 and 930 and further. Concentrations of Ocean Quahog are found mainly within a few miles of the shore, but Sea Scallop are fished commercially on the German Bank. Seaweeds, particularly Irish Moss and rockweeds, are harvested and processed in the southwestern part of the Unit. Fisheries are regulated as part of Fishing Zone 4. Productive salt marshes, mud flats, sand beaches, and offshore islands are significant wildlife habitat and provide recreational opportunities for field naturalists and hunters. Waterfowling in the fall is a traditional, regulated hunt for ducks and geese. Several provincial and federal wildlife management areas have been created on the coast (e.g., the Eastern Shore Island Wildlife Management Area). The coast is generally used for commercial shipping and recreational boating, and there are some military training areas (e.g., off Osborne Head).

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Associated Coastal Districts
810 Basalt Peninsula, 820 Cliffs and Beaches, 830 Beaches and Islands, 840 Quartzite Headlands, 850 Granite Barrens, 860 Sedimentary Lowlands, 870 Till Plain.

Associated Topics
T2.2 The Avalon and Meguma Zones, T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T10.9 Algae, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.6 The Ocean and Resources, T12.10 Plants and Resources, T12.11 Animals and Resources, T12.12 Recreational Resources.

Associated Habitats
H1 Offshore, H2 Coastal.

912 OUTER BAY OF FUNDY

GEOLOGY AND SEABED MORPHOLOGY

The Bay of Fundy is underlain by the Fundian Lowlands formation of Triassic sedimentary rocks. It can be divided into the Inner Bay (Unit 913), consisting of the semi-enclosed Minas Basin and Chignecto Bay, and the Outer Bay (Unit 912), the remaining portion that opens onto the Gulf of Maine. Bottom topography roughly parallels the coastline, sloping gradually away from it.

Tidal currents have formed significant surface features in the Outer Bay of Fundy/Gulf of Maine system, including extensive fields of sand waves, small ripple-like features, and isolated megaripples. The sandwaves are up to 18 m high and 183 m in length. An extensive field of sand waves occurs just east of Grand Manan Island at depths of 60–100 m and in scattered fields to the south and southwest of Lurcher Shoal (60–80 m). Large sand waves (up to 6 m high) with crests perpendicular to the tidal direction occur seaward of Minas Basin in Scots Bay.

SEDIMENTS

Shallower portions of the Outer Bay of Fundy have coarse sands and gravel "lag" formed when fine fractions of sediment are removed by currents. Deeper parts have a sandy bottom with silt and clay mixed in, and glacial till in the fringe areas.

The Outer Bay of Fundy lacks the intertidal mud flats and salt marshes of the inner reaches; the bottom consists of exposed bedrock and a coarse sand and gravel substrate winnowed by tidal currents. Rock formations in the Bay of Fundy are extensions of those that make up the shoreline. This area frequently has a range of wave-like bottom features, but often exposed bedrock occurs.

OCEANOGRAPHY

Tidal circulation predominates in the area. Secondary variations on tidal circulation occur seasonally because of freshwater runoff and the proximity of the slope water front. The ocean environment is determined by the environmental condition of Scotian Slope waters far offshore, tidal and residual currents, slope water incursions, and atmospheric influences (see T6.2). Storm waves can also be significant. The Outer Bay is cooler because of deeper water being brought to the surface by tidal action.

PLANTS

Seaweeds are distributed on rocky shores on both sides of the Bay of Fundy. The biomass is dominated by a small number of species of seaweed, including the rockweeds *Ascophyllum nodosum, Fucus vesiculosus, F. edentatus,* and *F. spiralis.* The extreme lower littoral and sublittoral zones are dominated by the kelps *Laminaria digitata, L. longicruris, Alaria esculenta,* and *Agarum cribrosum.*

A frontal zone at the south side of the mouth of the Outer Bay leads to high plant productivity, large populations of herbivorous and detritus-feeding animals, and eventually to concentrations of animals of higher trophic levels. The dominant intertidal alga is the rockweed *Ascophyllum nodosum.*

Tidal mixing at the mouth of the Bay of Fundy is important in the growth, during the summer months, of the dinoflagellates that cause paralytic shellfish poisoning.

ANIMALS

Major stocks of scallops (Digby Scallops) are found in nearshore waters off (and to the east and west of) Digby Neck, partially in response to the elevated productivity in the water. The area also supports strong lobster populations. Herring spend the summer feeding in nearshore zones. Witch Flounder are locally abundant in deeper waters at the mouth of the Bay of Fundy, and large spawning populations of Red Hake occur in Passamaquoddy Bay. Inshore concentrations of Atlantic Halibut are known around Grand Manan. Large populations of the euphausiid *Meganyctiphanes norvegica* are present near the mouth of the Bay of Fundy.

Species of bottom animals are similar to those in the Atlantic Unit 911, but the area has several localized concentrations of particular species, probably related to the tidal currents and rock bottom in some places. Dense beds of the Horse Mussel occur across the Outer Bay from inside Digby Neck to inside Saint John Harbour. Horse Mussels are the most important suspension-feeding organisms in the Unit. Concentrations of the brachiopod *Terebratulina septen-*

trionalis occur seaward of those areas in the central axis of the Bay of Fundy. The burrowing polychaete *Sternaspis scutata* and the tube-building amphipod *Haploops fundiensis* are common in silt-clay bottoms towards the outer portion on the New Brunswick side. The deep-sea Red Crab occurs in deeper parts of the area on mud, sand, or hard bottoms.

The Outer Bay of Fundy has been recognized as a feeding ground for Right Whales during the summer and autumn. The vicinity of Grand Manan Island is visited by a population of about 200 Northern Right Whales in summer, and they can be observed in Head Harbour Passage, Grand Manan Channel, and along the edges of Grand Manan Basin.

Southernmost breeding colonies of Atlantic Puffin and Razorbill occur on Machias Seal Island near Grand Manan Island in the Outer Bay of Fundy.

CULTURAL ENVIRONMENT

The highly productive waters of the Outer Bay of Fundy support important fisheries that form the economic basis of many communities. The summer herring fishery, scallops (Digby), and lobsters are most important. Lurcher Shoal is an important area for commercial scallop fishing. Herring are caught from the shore using weirs in some places, adding a distinctive feature to the coastal landscape. Harvesting of dulse, Irish Moss, and the rockweed *Ascophyllum nodosum* is locally important. Shell fisheries are usually closed in summer because of the danger of paralytic shellfish poisoning. The Annapolis Basin is the site of the first permanent European settlement in Canada (1605), and Digby remains a centre for marine fisheries and transportation. Bay of Fundy tides have been harnessed to generate electricity on the Annapolis River at Annapolis Royal. Tidal marshes have mostly been dyked and drained for farmland. The high productivity of the waters of the Bay of Fundy provide food for seabirds and marine mammals, including the Humpback Whale, which are important tourist attractions.

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Sites of Special Interest

- Brier Island—the waters off this island at the mouth of the Bay of Fundy are important feeding areas for seabirds, particularly phalaropes and shearwaters from July to September and murres and kittiwakes in the winter; in fall and winter the Red Phalarope is largely confined to restricted zones such as the tide-rips in the Bay of Fundy; Northern Right Whales are seen in summer
- Digby Neck area—intertidal populations of Common Periwinkle
- "French Shore" of Nova Scotia (St. Marys Bay)—known for coastal fog

Associated Coastal Districts and Units

311 Cobequid Hills, 710 Basalt Headlands, 810 Basalt Peninsula, 820 Cliffs and Beaches.

Associated Topics

T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.2 Cultural Landscapes, T12.10 Plants and Resources, T12.11 Animals and Resources.

Associated Habitats

H1 Offshore, H2 Coastal.

913 INNER BAY OF FUNDY

GEOLOGY AND SEABED MORPHOLOGY

The Inner Bay of Fundy comprises Cobequid Bay and Minas Basin (sub-Unit 913a) and Chignecto Bay (sub-Unit 913b). This Unit differs in many ways from the Outer Bay, particularly because of the effects of the high tides and the more sheltered environments there. Minas Basin and Cobequid Bay have extensive areas of intertidal mud flats, owing to the high tidal range, coastal erosion, and sediments brought in from several of the major rivers of Nova Scotia—the Salmon, Shubenacadie, Kennetcook, Avon, and Cornwallis rivers which flow into Cobequid Bay or Minas Basin, and the Petitcodiac River of New Brunswick which flows into Chignecto Bay. The coastlines of these basins have extensive salt marshes or dykelands. Beyond the mud flats in the subtidal zone, the bottom is variable in character, consisting in places of exposed bedrock, sand, and gravel and mud. The strong tidal currents create sea-bottom sand waves several metres in height and hundreds of metres in length.

In the intertidal zone of the Minas Basin is a complex series of sand waves, megaripples, and sand bars that reflect the locally strong tidal flows. These occur at Economy Point, Five Islands, and the Avon River estuary, and over wide areas subtidally.

SEDIMENTS

Glacially derived sediments comprise much of the seabed of the Inner Bay, but sediment derived from coastal erosion is important in some cases and accounts for local differences in bottom sediments, especially between Minas Basin and Chignecto Bay. Sediments in Minas Basin are principally sands and gravels, but intertidal and sheltered environments have muddy bottoms. The sand comes from the wave erosion of sandstone cliffs along the shoreline and from glacial outwash deposits. Chignecto Bay has extensive mud flats and the bottom is muddy, derived largely from shales on the nearby coasts.

OCEANOGRAPHY

The tidal force is predominant and, because of resonance, establishes a macro-tidal environment. Tidal mixing tends to minimize seasonal variations in temperature and salinity. Ice occurs in the upper reaches from December to April.

The Inner Bay of Fundy is estuarine in character and generally warmer than the Outer Bay, because of the pronounced warming of water as it moves over the mud flat, restricted circulation, and high turbidity. Suspended sediment levels in the Inner Bay of Fundy are high and significantly higher in Chignecto Bay than in Minas Basin. Phytoplankton productivity may be limited because suspended sediments make the water opaque.

PLANTS

Seaweeds are not generally abundant and occur in isolated patches where suitable hard bottom is present. *Fucus* species and *Ascophyllum nodosum* occur in the upper intertidal, and seaweeds of various kinds occur below extreme low water. A significant bed of the kelp *Laminaria saccharina* containing various seaweeds, including the dulse *Palmaria palmata* and coralline algae *Corallina officinalis*, has been found between Cape Blomidon and Medford Beach in western Minas Basin, and a dulse bed occurs near Parrsboro.

Phytoplankton populations are not generally as productive as in other Inner Shelf areas because light levels are reduced by high sediment loads in the Minas and Cumberland basins. The majority of plant production comes from microscopic algae growing on the surface of mud flats and from salt marsh grasses.

ANIMALS

The Inner Bay of Fundy supports large populations of various coastal fish species. Some migrate into the bay for feeding and reproduction, and others are resident in the area throughout the year. Most of the American Shad from east coast waters spend the summer in the basins of the Inner Bay of Fundy. More than 40 species of fish can be considered regular residents, some of the more common being Atlantic Herring, alewife, Blueback Herring, American Shad, smelt, Atlantic Tomcod, Atlantic Silverside, Windowpane, Smooth and Winter Flounder, Striped Bass, Atlantic Salmon, and American Eel. Waters are productive despite high turbidity and reduced phytoplankton production, be-

cause of the high abundance of zooplankton, which feed on detritus from salt-marsh grasses in suspension in the water. The mud flats are home to invertebrates, including numerous species of polychaete worms; softshell clams; intertidal snails; and crustaceans, including the tube-dwelling amphipod *Corophium volutator* (a small shrimp which is food for migratory shorebirds). Several species of flatfish, which live in the deeper water, come into the tidal flats and streams to reproduce and feed. Inshore concentrations of Atlantic Halibut at one time occurred in Minas Basin. Various seabirds occur, including gulls and cormorants, as well as various birds of prey (Ospreys and Bald Eagles) which use the coastal bluffs and nearby inland areas for nesting. Shorebirds in large numbers visit the mud flats on their passage north in spring and then return late in summer from Arctic breeding areas.

CULTURAL ENVIRONMENT

Both Minas Basin (sub-Unit 913a) and Cumberland Basin (in sub-Unit 913b) have muddy waters with generally poor fisheries, but the extensive tidal marshes are of great economic and cultural significance. Salt marshes are highly productive systems that support the fisheries of the Outer Bay of Fundy. These once-extensive marshes have been progressively dyked and drained since the seventeenth century to provide some of the finest agricultural land in the province. The dykes that protect the marshland from the sea must be constantly maintained, a task of increasing importance as the sea level continues to rise. There are some traditional fisheries of shad, shellfish (clams), and bait (bloodworms). Projects to generate electricity from the tides have been proposed for both Cumberland Basin and Cobequid Bay.

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Sites of Special Interest

- Most major rivers entering the Inner Bay of Fundy—tidal "bores"; extensive areas of mud flats and beaches extend out from shore
- Minas Channel between Cape Split and Rams Head near Parrsboro—significant tidal currents flow into the outer reaches of Chignecto Bay; shifting sea ice is a significant winter feature
- Coastal areas—extensive dykelands and salt marsh; concentrations of shorebirds, chiefly Semipalmated Plover, can be observed on mud flats in the spring and late summer
- Grand Pré—extinct oyster bed at extreme low water mark reflects the progressively changing environment of Minas Basin, though several warm-water species, including Lady Crab and Angel Wing Clam, remain as disjunct populations in the area

Associated Coastal Units and Districts

523 Tantramar Marshes, 532 Chignecto Plains, 540 Clay Plain, 610 Valley, 620 Tidal Bay, 710 Basalt Headlands, 720 Basalt Ridge.

Associated Topics

T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T6.4 Estuaries, T11.4 Birds of Prey, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.10 Plants and Resources.

Associated Habitats

H1 Offshore, H2 Coastal.

914 NORTHUMBERLAND STRAIT

GEOLOGY AND SEABED MORPHOLOGY

This Unit consists of the Northumberland Strait and the southeastern Gulf of St. Lawrence between Prince Edward Island and Cape Breton. The coastlines of the western portion are low and featureless, and the steep terrains of the Antigonish and Cape Breton highlands border the area to the east. Underlying Northumberland Strait is a system of troughs and depressions, including a continuous trough along the axis. At the eastern end, water depth gradually increases in the direction of the Laurentian Channel. Between Wood Islands and Caribou this trough is 3.5 km wide and has a series of depressions to 90 m. The bridge to Prince Edward Island at Cape Tormentine crosses a maximum depth of about 30 m. The trough extends along the Cape Breton coast and reaches a depth of 90 m in the north, adjacent to the Laurentian Channel.

Western parts of the Unit are underlain by horizontal or gently folded sedimentary rock of Upper Carboniferous and Permian age, while folded and faulted Ordovician to Middle Carboniferous rocks of the Antigonish and Cape Breton highlands extend under St. Georges Bay and to about 16 km offshore at the eastern end. Prince Edward Island was separated from the mainland as the result of the drowning of a pre-glacial river valley system that was later enlarged by glacial erosion. The low coastlines of the Unit consist of sandstone cliffs, intertidal platforms with sand and mud deposits, barrier islands, and beaches. This area has a generally sheltered wave environment, small tides (0.5–2 m), and a relative abundance of sediments. The sea bottom in the area is sculpted into a variety of features, including sand waves, megaripples, and sand ridges.

SEDIMENTS

The Gulf of St. Lawrence, including Northumberland Strait, has patches of reworked sand and gravel, glacially derived marine silt, and clays at greater depths. Sediments originated largely during the post-glacial period as the sea transgressed the area and reworked material deposited during the glaciation, but sediments originate locally through erosion of coastal bedrock. Local sand deposits in the littoral zone arise in part from sandstone deposits along the coast. Little sediment is supplied to the coast by rivers owing to the small size of the drainage systems.

OCEANOGRAPHY

The major driving forces for circulation are freshwater runoff, winds, and tides. The surface currents flow from west to east (from Gaspé to the Cabot Strait). Currents are generally weak and shallow depths prevail. The ocean environment exhibits a large temperature range from winter to summer. Ice forms in winter to thicknesses of as much as 120 cm, and water temperatures fall to approximately -1°C. In summer, mixing is constrained by shallow depths and stratification, and open-water temperatures reach 20°C. Erratic tides are diurnal or semi-diurnal, ranging from 1.1–2.9 m.

The Northumberland Strait has warmer water temperatures in summer than other continental shelf regions of Nova Scotia. Temperatures in winter are comparatively colder due to extensive winter ice and low surface salinities in spring. The west- and north-facing coasts of Northumberland Strait are exposed to higher wave energy levels than east-facing shorelines because wave heights increase from west to east. Beaches and intertidal zones are affected by ice from mid-December to April or May of each year.

PLANTS

Seaweeds are diverse and moderately abundant on exposed rock surfaces but not as abundant as in other Inner Shelf areas because of winter ice scouring. However, the red seaweeds *Furcellaria* and Irish Moss are abundant enough to be commercially exploited. Irish Moss occurs throughout Northumberland Strait from the sublittoral to 12 m in depth. The warm coastal waters allow several warm-water species to survive, including *Gracilaria tikvahiae, Stilophora* spp., *Dazilea* spp., *Chondria* spp., *Griffithsia globulifera,* and *Lomentaria baileyana.*

Phytoplankton in Northumberland Strait include diatoms (most abundant) and dinoflagellates. Diatoms tend to dominate blooms (typically

in spring and fall), and the other groups dominate at other times of the spring-to-fall period.

Eelgrass beds develop subtidally adjacent to shore and in coastal bays and estuaries in areas having fine substrate. In many areas the Eelgrass is scoured during winter by sea ice. In some embayments, salt marshes occur with other halophytic vascular plants.

ANIMALS

The Northumberland Strait is shallow enough in areas to support species of plants and animals associated with warm, shallow water. Among the nearshore invertebrate fauna is a shallow warm-water fauna which includes a group of benthic invertebrates associated with American Oyster.

The Unit has relatively high levels of primary and secondary productivity and supports a range of species of invertebrates, fish, and algae.

Key fish species include American Plaice, herring, mackerel, cod, Winter Flounder, White Hake, alewife, silversides, smelts, and Atlantic Salmon. Atlantic Salmon occur in many of the rivers, and Capelin spawn in the intertidal-to-immediate subtidal waters in localized areas near Chéticamp and in the St. Georges Bay area. Localized winter fisheries for smelt occur in bays and estuaries along Northumberland Strait. Other species include redfish, Witch Flounder, Yellowtail Flounder, American Eel, and Thorny Skate. Witch Flounder are plentiful on smooth muddy bottoms northeast of Prince Edward Island and just west of Cape Breton Island. Bluefin Tuna can occur in the fall in the southeastern Gulf of St. Lawrence, particularly St. Georges Bay.

Sea Scallop are distributed throughout Northumberland Strait and major concentrations occur in the Caribou/Wood Islands area. The American Oyster is native to coastal areas of Northumberland Strait where it is restricted to the shallow inshore waters of protected bays and estuaries. Oysters can tolerate low winter temperatures and summer temperatures up to 32°C but require warm summer temperatures to reproduce and grow. Lobster are also abundant in the area. Productive soft-shelled clam flats are found in Northumberland Strait, particularly in protected bays and estuaries. Adults live in sediments which range from clean, medium fine sand and anaerobic mud to mud and gravel. Snow Crabs occur on muddy bottoms between Prince Edward Island and Cape Breton and extend through Cabot Strait into Sydney Bight (Unit 915). Other invertebrates include Rock Crab, Ocean Quahog, and Softshell Clam.

Grey and Harbour seals and Harbour Porpoise are found year-round in nearshore areas. Harp and Hooded seals can be found on ice in the Gulf of St. Lawrence and may drift through the Unit. Grey Seals are known to whelp in the vicinity of Pictou Island, and many can be found on ice in the Northumberland Strait.

Whales and porpoises enter the area in spring, feed through the summer, and leave in winter. A range of species occurs, including Killer Whale, Pilot Whale, Blue Whale, Minke Whale, Fin Whale, Atlantic White-sided Dolphin, and White-beaked Dolphin.

CULTURAL ENVIRONMENT

The warm summer water temperatures of the Northumberland Strait support a warm-water fauna which includes shellfish of commercial importance: lobsters, Snow Crab, Softshell Clam, quahogs, and oysters harvested from natural populations. Offshore are scallop and ground fisheries, seasonal pelagic fisheries (e.g., tuna), and the harvested seaweeds *Furcellaria* and Irish Moss. These are all small boat fisheries from many small harbours (e.g., Toney River and Ballantines Cove). Fisheries are managed as part of Fishing Zone 1. Aquaculture for Blue Mussels is becoming important in the warm bays. Marine life and bird- and whale-watching, particularly based from the Cape Breton Highlands National Park, are important for tourism. There is considerable recreational and commercial vessel traffic in the summer.

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Sites of Special Interest

- Eastern Prince Edward Island and St. Georges Bay—Bluefin Tuna migrate into the southern Gulf of St. Lawrence and may be caught here in the fall
- Pictou Causeway between Trenton and Pictou—colony of cormorants on old bridge pilings

Associated Coastal Districts and Units

210 Plateau–Fir Forest, 220 Steep Slopes, 312 Pictou-Antigonish Highlands, 314 Mabou Highlands, 521 Northumberland Plain, 522 Judique Coastal Lowland, 551 Inverness Coastal Plain, 582 Pictou Valleys, 583 Antigonish Uplands, 592 St. Lawrence Slopes.

Associated Topics
T2.7 Offshore Geology, T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T6.4 Estuaries, T10.9 Algae, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.10 Plants and Resources, T12.11 Animals and Resources.

Associated Habitats
H1 Offshore, H2 Coastal.

915 SYDNEY BIGHT

GEOLOGY AND SEABED MORPHOLOGY

This Unit extends from the eastern extension of Cape Breton Island, in the vicinity of Scatarie Island, to Cape North on the northern tip of the island. It is underlain mainly by Carboniferous rocks of the Maritime plain, a continuation of onshore geological formations and part of the Carboniferous-Triassic lowlands. Rocks of the Sydney Basin (which contain the onshore coal formations in the Sydney area) extend northward to Newfoundland, where they emerge in Georges Bay. Nearshore rocks in the northern portions are igneous where the Cape Breton highlands extend under the sea. The relatively flat bottom which slopes only gradually offshore in Sydney Bight forms St. Anns Bank, the only major bank in the Inner Shelf zone.

SEDIMENTS

Sediments at depths of less than 100 m are sand and gravel mixtures, frequently in a thin layer through which bedrock is exposed. Deeper parts fall in the Middle Shelf (Unit 923) and are chiefly sands containing silt and clay (Sambro Sand). Nearshore deposits are formed of material eroded from coastal bedrock, and local hydrographic conditions can lead to the development of deposits of sand, gravel, clay, and other materials in some cases.

OCEANOGRAPHY

Especially in summer this area is influenced by the warmer, fresher waters that flow from the Gulf of St. Lawrence. In winter and spring the area is exposed to sea ice which moves out of the Gulf of St. Lawrence.

PLANTS

Many common seaweed species of the Atlantic coast are represented at shallow depths, including the kelps *Laminaria longicruris, L. digitata, Sacchorhiza dermatodea,* and *Agarum cribrosum,* the rockweed *Fucus* spp. and Irish Moss (*Chondrus crispus*). The latter two occur more frequently and kelps occur less frequently on Sydney Bight coasts than Atlantic coastal areas (Unit 911). The coast from Mira Bay to Great Bras d'Or Channel is sandstone, which is less suitable for attachment of seaweeds.

ANIMALS

Atlantic Cod form dense wintering concentrations in deep water in the area and move into the southern Gulf of St. Lawrence in spring to spawn.

Concentrations of Snow Crab occur on soft bottoms on the Middle Shelf (Unit 923) surrounding Sydney Bight. Populations extend at suitable depths to the west of Cape Breton Island into the Northumberland Strait (Unit 914). Colonial seabirds such as puffins occur on the northern reaches of Cape Breton Island. The offshore waters have seabirds in summer which include puffins, shearwaters, and kittiwakes, and winter distributions of fulmars, kittiwakes, and murres.

CULTURAL ENVIRONMENT

In addition to fishing, considerable industrial and transportational use is made of the waters of Sydney Bight. Fisheries include lobster, Snow Crab, and ground fisheries, and Capelin have recently been coming to the shores to spawn in early summer, providing a small recreational fishery. Industrial plants, electricity-generating stations, and urbanization have created several forms of pollution in the coastal water. Some fine beaches (e.g., Dominion), the scenic east side of the Cape Breton highlands, and wildlife (e.g., Bird Islands) are important tourist attractions. There is heavy marine traffic, including the Newfoundland ferries and vessels en route to and from the St. Lawrence River.

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Sites of Interest

- Bird Islands (IBP Proposed Ecological Site 24)—bird nesting sight, with rare arctic-alpine plants
- Point Aconi and area

Associated Coastal Districts and Units

210 Plateau–Fir Forest, 220 Steep Slopes, 552 Victoria Coastal Plain, 531 Sydney Coalfield.

Associated Topics
T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T6.4 Estuaries, T10.9 Algae, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T12.11 Animals and Resources.

Associated Habitats
H1 Offshore, H2 Coastal.

916 BRAS D'OR LAKE

The Bras d'Or Lake comprises an irregular brackish body of water covering 260 km². The western part of the lake is generally shallow, with the sheltered bays of West Bay, Denys Basin, and Whycocomagh Bay. Three long narrow arms extend to the east: East Bay, St. Andrews Channel, and Great Bras d'Or Channel. Great Bras d'Or Channel connects to the open sea in the Sydney Bight across a depth of at least 8 m. Little Bras d'Or Channel is a 6-m deep, sinuous estuary that connects St. Andrews Channel with the sea. A narrow isthmus at St. Peters separates the southern part of Bras d'Or Lake from St. Peters Bay.

GEOLOGY AND SEABED MORPHOLOGY

There is no direct information on the bedrock geology beneath the Bras d'Or Lake. Extrapolation of observations along the shoreline and in the adjacent lowlands suggests that the lakes are largely underlain by Carboniferous Windsor Group sedimentary rocks, principally shale, sandstone, gypsum, and salt. A large negative gravity anomaly beneath West Bay suggests the presence of salt.

The Bras d'Or Lake occupies a regional lowland that developed in soft Windsor Group rocks before the Quaternary glacial period. Some deepening of the floor of the lake might have resulted from solution collapse of gypsum, but the main excavation of the very deep channels (280 m in St. Andrews Channel, 81 m in East Bay) appears to be a consequence of glacial erosion, probably over hundreds of thousands of years through the Quaternary. The cliffs bordering the lake are unusual because they preserve organic sediments predating the last glaciation that provide a window on earlier environmental conditions.

The morphology of the lake floor is influenced by the deposition of glacial till and pre-glacial silty muds that occurred during the last retreat of ice. The extensive drumlin field of southern Cape Breton Island extends across much of the central and western parts of the lake. Remaining ice appears to have been centred on the western part of Bras d'Or Lake, and a series of recessional moraines are visible on the floors of East Bay, St. Andrews Channel, and Great Bras d'Or, with pre-glacial silty muds thickening eastward.

Post-glacial History

The shallowness of the links between the Bras d'Or Lake and the Atlantic Ocean have resulted in a complex post-glacial history. Final melting of glacial ice probably occurred about 10,000 years after the Younger Dryas climatic oscillation. The first sediments deposited above glacial till in the central part of the lake, probably 10,000 to 9,000 years ago, contain dinocysts that indicate some penetration of marine water into the lake. The relatively high sea level inferred at this time reflects the continuing depression of the land from loading by glacial ice. Rebound from this depression cut off marine-water influx from about 9,000 to 4,500 years ago and the Bras d'Or Lake was fresh. Late Holocene subsidence resulted in a renewed influx of marine water in the last 4,500 years. The effects of this subsidence are seen in the transgressive character of many of the shoreline features and the extensive shoals of upper Whycocomagh Bay, Nyanza Bay, and Denys Basin, which lay at the mid-Holocene lake shoreline.

SEDIMENTS

Sediment distribution in the Bras d'Or Lake is similar to that found in many of the larger coastal inlets on the southern shore of Nova Scotia. Deeper areas of the lake are floored by mud, except for the sands found in some areas flushed by tidal currents. More exposed shallow areas of the western part of the lake are commonly floored by gravelly, sandy mud that resulted from the erosion of glacial till. Coastal erosion of glacial sediments has led to the formation of many sandy and gravelly barrier beaches and spits.

OCEANOGRAPHY

Bras D'Or Lake is a fiordal system connected to the sea via two restricted channels. This restricted access causes the tidal amplitude to be reduced and, in combination with high freshwater runoff, results in relatively low salinity. The salinity of surface waters vary from about 29 p.p.t. at the entrance to Great Bras d'Or, to 25–26 in the deep water basins, to 20–21 in surface waters at the east end of East Bay. Lower salinities are found in sheltered bays off the larger rivers that drain into the western part of the lake. A thermocline and halocline develop at 10–20 m during the summer and

probably deepen in the winter. Measurements of oxygen and salinity indicate that lake water is a mix of Atlantic water and local runoff, with an insignificant contribution from groundwater. Most of the lake is covered by ice in winter, with temperatures warming by more than 10°C from May to July.

The Bras d'Or Lake shows a typical estuarine circulation, with brackish near-surface waters tending to flow seawards, and deep saline water tending to flow into the lake. Tidal currents in the entrance to Great Bras d'Or are normally 4–5 knots but reach 6 knots or more when the lake level is elevated by up to 30 cm during spring runoff or after northeast gales. Non-tidal flows in the lake proper tend to be very weak but in narrow passages between basins may reach about one knot. The long fetches in the eastern arms of the Bras d'Or Lake allow sizeable waves and swells to develop during northeast gales.

PLANTS

Seaweed species are similar to those of the Gulf of St. Lawrence. In both areas, seaweeds usually found in intertidal zones occur only in deeper water as the result of winter ice activity, and the rockweed *Ascophyllum nodosum* is found subtidally. Sheltered bays have marginal salt to freshwater marsh vegetation.

ANIMALS

The Bras d'Or Lake is one of the areas where the American Oyster is found, owing to warmer water temperatures suitable for growth and reproduction. A significant population of sand shrimp, a southern species, exists here. The polychaete fauna is Virginian in character but also includes some arctic-boreal species. A varied fish fauna includes Blueback Herring, Black-spotted Stickleback, and a southern population of Greenland Cod. A feral population of Rainbow Trout is present in the lake as well. These support strong populations of Great Blue Heron, Double-crested Cormorant, and Bald Eagle.

CULTURAL ENVIRONMENT

Most cultural use of the Bras d'Or Lake is related to shore-based activities. The whole area is of high cultural significance to the Mi'kmaq people and is a centre of Scottish heritage in Nova Scotia. The marine area has some natural fisheries, but aquaculture for oysters and salmonids is most important. The area is important for recreational boating.

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Associated Coastal District and Unit
560 Submerged Lowland, 585 Iona Uplands.

Associated Topics
T3.3 Glaciation, Deglaciation and Sea-level Changes, T6.2 Oceanic Environments, T6.4 Estuaries, T10.9 Algae, T11.4 Birds of Prey, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.2 Cultural Landscapes, T12.11 Animals and Resources, T12.12 Recreational Resources.

Associated Habitats
H2 Coastal.

920 MIDDLE SHELF

The Middle Shelf District has been divided into three Units:

921 Middle Shelf Banks
922 Middle Shelf Basins
923 Valley and Plains

GEOLOGY AND SEABED MORPHOLOGY

The Middle Shelf extends roughly from a depth of 110 m near shore to the inner edges of the major offshore banks (Baccaro, LaHave, Emerald, Western, Sable Island, Banquereau, and Georges). Definition of the Middle Shelf District is based on the physiography of the Scotian Shelf but has been extended to include the Gulf of Maine within the same depth ranges. It belongs to the submerged Atlantic Coastal Plain, and its topography was determined by erosional and tectonic processes while it was above sea level. On the Scotian Shelf (the continental shelf south of Nova Scotia), the inner margin of the Middle Shelf is a trough from 145–180 m deep and 40–50 km wide. Outside the trough is a zone that has three broad basins (Roseway, LaHave, and Emerald) and contains isolated deep banks (Roseway and Sambro) on the western end (of 80–100 m depth), and on the east several banks (Middle, Canso, Misaine, and Western Banquereau) separated by valleys and intervening ridges. The banks have a cover of Quaternary and Cretaceous material over a Meguma basement (see Figure 31).

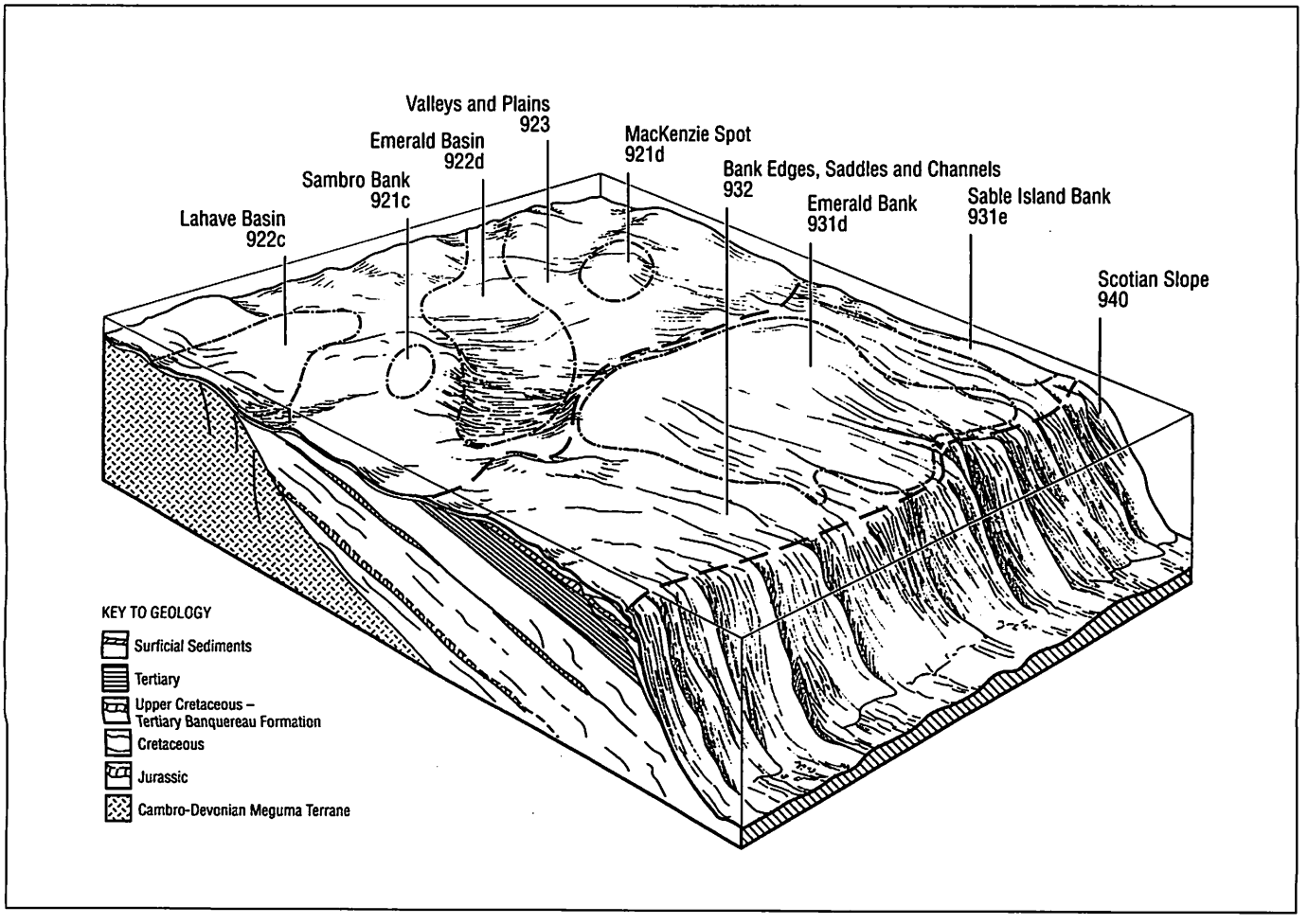

Figure 31: Emerald Basin and Emerald Bank area of the Offshore/Continental Shelf (Region 900). The eroded landscape of the Tertiary and Cretaceous rocks is overlain by glacial deposits.

In the Gulf of Maine, the Middle Shelf includes a series of basins that extend from Northeast Channel (which separates Georges Bank from Browns Bank) through a series of smaller basins to Grand Manan Basin. This section falls into two geological provinces. The northern part is in the Fundian Lowlands, of which the Bay of Fundy is a part; this series of basins may reflect a former drainage pattern which started in the Bay of Fundy and went out over the shelf. The southern part (Georges Basin and Northeast Channel) is part of the Atlantic Coastal Plain (which is similar geologically to the Scotian Shelf).

SEDIMENTS

Middle Shelf areas have sediments derived from glacial activity, and subsequent reworking by an advancing sea level at the end of the glacial period. Bank areas to depths of 110–120 m have coarse sediments of sand, gravel, and occasional boulders. On the bank edges, the bottom is made of sands that have clay and silt. Basins have clay and localized occurrences of silt. The shoreward flanks of the basins have glacial till deposits, and a string of moraine deposits extends from off Country Harbour into the Gulf of Maine.

OCEANOGRAPHY

The Middle Shelf may be subdivided on the basis of water masses into a Scotian Shelf portion and a Fundy/Gulf of Maine portion. Both have the general seasonal pattern described elsewhere for continental shelf areas. Temperatures and salinities in the Middle Shelf tend to be intermediate between those for the Inner Shelf and the Outer Shelf. The influence of the Nova Scotia Current is felt all along the Middle Shelf into the Gulf of Maine. In the Gulf of Maine, there are frontal zones at the northern edge of Georges Bank and a front is induced by tides at the outflow of the Bay of Fundy just offshore. These zones have led to high biological productivity and have an important effect on the distribution and movement patterns of several fish species.

PLANTS

Phytoplankton are the main plants in the Region and are found chiefly in the upper or "mixed" layer of the ocean where turbulence keeps them suspended. Coralline algae form pale to pinkish crusts on rock and gravel surfaces on the banks. Productivity is generally not as great as nearer to shore or closer to the edge of the continental shelf, but several locations have significant production (e.g., the northern edge of Georges Bank and the eastern side of the Gulf of Maine off southwestern Nova Scotia). Much of the productivity of the Middle Shelf takes place in a "bloom" in the spring from late March to May. The abundance of plants stabilizes at a lower concentration during the summer and usually peaks in the fall. Over the winter, concentrations drop as the mixed layer dissipates. The Middle Shelf also contains occasional drifting seaweeds derived from interactions with slope water and the Gulf Stream much further offshore.

ANIMALS

The Middle Shelf has fewer organisms than the Inner Shelf and a relative absence of filter feeders (except on banks and shallow areas) and animals that graze on seaweeds (e.g., sea urchins). Bottom sediments are also generally finer in the Middle Shelf, especially in the basins, and soft-bottom animals are relatively more important than on the Inner Shelf. Animal communities are diverse and contain a broad range of species and types typical of continental shelf oceanic environments of the Northwest Atlantic.

Animals on the Middle Shelf receive their energy either directly or indirectly from sunlight captured by phytoplankton in the surface waters. Zooplankton are adapted almost exclusively to feeding on phytoplankton and are represented principally by copepods such as *Calanus, Metridia,* and *Oithona.* Several kinds of zooplankton, including hyperiid amphipods, krill, arrow worms, and jellyfish feed on copepods and other zooplankton. Several of these groups have representatives which feed on the seabed, but they are a minor component.

Most bottom-dwelling invertebrates spend their early life stages in the water column, where they feed on phytoplankton and in many cases shift to a diet of zooplankton before they return to the seabed. The shift to the warmer temperatures of the surface waters enhances growth. Some lobster stocks occur on the Middle Shelf. Lobster commonly move into the basins of the Middle Shelf and to the Outer Shelf banks and continental slope.

Many of the fish species feed directly on zooplankton during their early life stages. The eggs of species such as cod and haddock float and are in surface waters when they hatch. The young fish stay near the ocean surface for a time before they shift to living near the bottom. The young of many of the so-called groundfish are often distributed over or near banks, suggesting that spawning takes place there.

Various fish and whale species may pass through the Middle Shelf en route to areas just beyond the boundaries of the Region, and octopuses may occur in the deep basins.

CULTURAL ENVIRONMENT

Fishing banks in this District (e.g., Sambro Bank and Roseway Bank) are important bottom fishing grounds for summer inshore fishing. Some banks at the western end are included in the "offshore" lobster fisheries. The area contains submarine cables. Some localities have been used for the dumping of munitions.

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Associated Topics
T2.2 The Avalon and Meguma Zones, T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.11 Animals and Resources.

Associated Habitats
H1 Offshore.

921 MIDDLE SHELF BANKS

Banks on the Middle Shelf include:

- 921a Grand Manan Bank
- 921b Roseway Bank
- 921c Sambro Bank
- 921d MacKenzie Spot
- 921e Middle Bank
- 921f Canso Bank
- 921g Misaine Bank
- 921h Artimon Bank

GEOLOGY AND SEABED MORPHOLOGY

The Middle Shelf Banks are generally underlain by bedrock features in the Meguma formation and overlain by Quaternary and Cretaceous material. Middle Shelf banks vary in depth, surface sediments, and morphology. The Roseway and Sambro banks, which separate the Roseway, LaHave, and Emerald basins in Unit 922, are steep-sided, flat-topped mesas at 80–100 m depths. Other banks (Middle, Canso, Misaine, and the western part of Banquereau) appear to be cuestas with more gradually sloping margins. The western part of the Middle Bank is part of the Country Harbour moraine, one of a series of submarine glacial features found on the inner edge of the Middle Shelf (see T3.3 and Unit 922). The surface of Misaine Bank on the northeast end of the Scotian Shelf is extensively incised by channels believed to have resulted from the melting of the ice sheet. Other bank tops were levelled during the post-glacial sea-level advance as they became successive beach zones.

SEDIMENTS

Bottom sediments on the tops of the banks are a coarse deposit known as Sable Island Sand and Gravel, which contains sand and rounded gravel in various mixtures at the surface and has glacial till (Scotian Shelf Drift) beneath. Most of the smaller banks (Sambro, Roseway, The Patch) have a cover of predominantly gravel containing various proportions of sand at depths shallower than 110 m. In contrast, the larger Middle and Misaine banks have, in addition to areas of gravel bottom, a surface cover of chiefly sands with gravel mixed in. Both types of bottom are part of the Sable Island Sand and Gravel formation. The gravel can form a protective pavement of rounded stones embedded in the bottom. The sand tends to be smooth, hard, and flat and to have a variety of surfaces.

The margins of the banks at depths below 110 m have principally sandy sediments that contain small amounts of clay and silt, and frequently gravel. The surface may be flat and smooth to undulating and hummocky. These deposits are called Sambro Sand.

OCEANOGRAPHY

Currents derived from tides form a gyre around the banks and provide a potential though yet unproven means of keeping the larvae of fish species in the vicinity as they mature. Tidal action also tends to produce a mixed water column on banks. The water column on the shallower banks may be well mixed through much of the year, while the deeper banks have a stratified water column.

PLANTS

Plant life follows that of the District description. There does not appear to be a difference in plant production on banks and adjacent basins and channels.

ANIMALS

The coarse sand and gravels of bank tops favour large bivalve species such as the Ocean Quahog and Stimpson's Surf Clam which are less abundant on the Roseway and Middle banks. Concentrations of Sea Scallop also occur on some of the banks of the eastern Scotian Shelf. Bottom invertebrate communities characterized by the Horse Mussel, the Brittle Star *Ophiopholis aculeata*, Sea Scallop, lobster, and the Toad Crab are expected to occur on the coarse substrate in these areas. Sandier areas such as Canso Bank include organisms such as the sand dollar *Echinarachnius parma* and the amphipods *Unciola irrorata* and *Leptocheirus pinguis*. Sand Lance also favour this type of substrate.

Storm-petrels, shearwaters, jaegers, and phalaropes are found in the summer, and murres and kittiwakes are present in the winter.

CULTURAL ENVIRONMENT

Small banks on the Middle Shelf are important for trawling and line fishing from vessels from many small ports. The various local names (e.g., Mackenzie Spot, The Patch, The Bull Pen) come from long use. Some of the earliest records of molluscs reported by J.R. Willis in the 1860s were brought to him from Sambro Bank by local Halifax fishermen.

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Associated Topics
T3.3 Glaciation, Deglaciation and Sea-level Changes, T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.11 Animals and Resources.

Associated Habitats
H1 Offshore.

922 MIDDLE SHELF BASINS

Basins on the Middle Shelf include:

922a East Jordan Basin
922b East Georges Basin
922c LaHave Basin
922d Emerald Basin
922e St. Anns Basin

GEOLOGY AND SEABED MORPHOLOGY

These basins are extensive depressions in the Middle Shelf and are similar to lowlands. They have been extensively filled and smoothed by sedimentation and the action of the ocean. Collectively, their landward edges form a trough that runs parallel to the Atlantic coast of Nova Scotia and is analogous to lowland areas of the emerged coastal plain south of New Jersey.

Basins in the Gulf of Maine tend to be larger and deeper, and are frequently separated by sill-like features typified by the Truxton Swell between Jordan and Crowell basins. Other prominent basins in the Gulf of Maine are Grand Manan Basin (at the mouth of the Bay of Fundy) and Georges Basin (off the northern edge of Georges Bank).

Submarine glacial end moraines occur on the landward flanks of the Middle Shelf basins on the Scotian Shelf, and in the form of the Fundian Moraine that reaches between Crowell and Georges basins in the Gulf of Maine. This complex of moraines extends more than 800 km, from the Gulf of Maine to the Laurentian Channel. These moraines differ from those found on land because they were formed while an ice sheet floated over seawater, and the morainic material was deposited into marine conditions. Some of these moraines have furrows from ancient icebergs that grounded when the water was shallower.

SEDIMENTS

The main sediment of the basins is a grey clay known on the Scotian Shelf as LaHave Clay, which formed during glacial retreat and settled to the seabed in the reduced currents and waves of the basins. Occasionally boulders pierce the cover where they were dropped from the bottoms of melting glaciers, and crater-shaped depressions known as pockmarks are found where natural gas from subsurface rock formations bubbles to the surface. Beneath the clay are layers of silt (Emerald Silt) carried by meltwater from the advancing glaciers and spread throughout the basins. In some places, Emerald Silt has been exposed at the surface. The upper levels of the basins frequently have deposits of glacial till, which also occurs in the moraines in the inner flanks of the basins. The glacial till is classed as Scotian Shelf Drift and was not modified by the last advance of the sea across the continental shelf.

OCEANOGRAPHY

Middle Shelf basins are connected with the Outer Shelf (District 930) and the edge of the continental shelf through "saddles," areas of intermediate depth which separate the banks of the Outer Shelf. The saddles are at depths of less than 200 m but generally more than 100 m and form an entrance to the basins for subsurface water masses. Frequently, storms will force warmer, deeper slope water from the shelf edge into the basins. Middle Shelf basins in the Gulf of Maine have a deeper connection with the Outer Shelf through the Northeast Channel between the Browns and Georges banks, at depths over 200 m. Owing to the greater influence of the tides in the area, significant currents and a larger transport of water occurs through the Northeast Channel into the basins.

PLANTS

Movements of water through the Outer Shelf saddles into the basins of the Middle Shelf bring periodic influxes of nutrients which help to sustain phytoplankton populations. Basin bottoms are too deep to sustain plant growth. Plant productivity in the water over the basins is similar to that over the banks.

ANIMALS

The deep basins on the Scotian Shelf contain high concentrations of the copepods *Calanus glacialis* and *C. hyperboreus* at depths below 200 m, and the populations are greater than on the adjacent shelves. These basins make it possible for *C. finmarchicus* to dominate the shelf zooplankton for most of the year. Two of the largest basins, Emerald and LaHave, contain large populations of Silver Hake, and a large euphausiid (krill) population occurs in Emerald Ba-

sin. The juvenile Silver Hake feed principally on young euphausiids (*Meganyctiphanes norvegica*). Red Hake are common in deeper portions of the southwestern Scotian Shelf and the Gulf of Maine, and Witch Flounder occur in deep holes and channels between the coastal banks and along the deep edges of the banks where water temperatures are suitable.

Invertebrates on the soft bottom of the basins include the Brittle Star *(Ophiura sarsi)*, the Heart Urchin, the Mud Star *(Ctenodiscus crispatus)*, Northern Shrimp, the anthozoan *Pennatula aculeata*, Snow Crab, Jonah Crab, and Tusk Shell (*Dentalium* spp.). Polychaete worms which live in bottom sediments of the basins are part of the Labrador faunal group, while those in shallower water are Acadian, or warmer water forms.

Snow Crab occur on muddy or sandy mud bottoms at depths of 45–245 m around Cape Breton Island. Significant populations of shrimp (*Pandalus borealis* and *P. montagui*) occur over deep muddy bottoms in the basins between Middle, Canso, and Misaine banks, and in basins north of Misaine Bank).

The endangered Northern Right Whale is often seen on the Scotian Shelf, especially in or near Roseway Basin (Unit 923) between Browns and Baccaro banks.

CULTURAL ENVIRONMENT

The deeper basins are used to some extent for fishing, including for Northern (Pink) Shrimp. The most important fishery is that for Snow Crab around Cape Breton Island. There are munitions dumping areas (e.g., sub-Unit 922d, Emerald Basin).

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Associated Topics
T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T.12.11 Animals and Resources.

Associated Habitats
H1 Offshore.

923 VALLEYS AND PLAINS

GEOLOGY AND SEABED MORPHOLOGY

This zone occurs between depths of 100 and 200 m. It contains the intervening areas of bottom between the Middle Shelf banks and the basins. No distinctions have been made between the bedrock geology of this zone and that of the two previous Units, but this Unit contains various glacial features associated with the basin flanks, including submarine moraines and relict iceberg scours. Because of the sloping terrain, the area is probably subject to phenomena such as slumping.

SEDIMENTS

The upper levels of the basins frequently have deposits of glacial till, which also occurs in the moraines on the inner flanks of the basins. This Unit also frequently contains sands mixed with clay and silt, in contrast to the well-sorted deposits of the banks. These deposits may be flat and smooth to undulating and hummocky, and on the Scotian Shelf are called Sambro Sand.

OCEANOGRAPHY

Oceanographic features are as in the regional description.

PLANTS

This Unit occurs below the depth of seaweed growth, and phytoplankton is the principal vegetation.

ANIMALS

Fauna in the water column reflect that in adjacent basins and banks.

CULTURAL ENVIRONMENT

These intermediate areas between the banks (Unit 921) and basins (Unit 922) are used for bottom trawling and line fishing for species such as American Plaice, Witch Flounder, and Yellowtail Flounder.

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Associated Topics
T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T.12.11 Animals and Resources.

Associated Habitats
H1 Offshore.

930 OUTER SHELF

This District has been divided into two Units:

931 Outer Shelf Banks

932 Bank Edges, Saddles, and Channels

GEOLOGY AND SEABED MORPHOLOGY

The Outer Shelf is a broad zone (50–75 km wide) consisting of banks and intervening areas (saddles, channels, and one major submarine valley, The Gully) extending from Banquereau on the east to Georges Bank on the west. The main banks (Banquereau, Sable, Emerald, LaHave, Browns, and Georges in Unit 931) are relatively large, shallow (30–80 m), and more or less flat-topped. They represent features in the ancient bedrock that were overlain with glacial till and then levelled by the advancing sea following the last glaciation. Sable Island (District 890) protrudes to a height of 26 m above the surface of the Sable Island Bank and is the furthest offshore island. The relief of the banks relative to other features of the Outer Shelf is comparable to areas of the mainland today—the elevations of the outer banks are generally less than those of the Cobequid Mountains in the Wentworth area of Cumberland County and much less than the Cape Breton highlands. However, The Gully—a submarine canyon between Sable Island Bank and Banquereau—is about half as deep as the Grand Canyon in the United States.

SEDIMENTS

The bank tops contain sand and gravel deposits and, in the case of Sable Island, have been reworked and moved around to form extensive sand fields. Below a depth of about 110 m, the bottom sediment consists of sand with silt and clay mixtures. The Outer Shelf contains no basins, and the only clay deposits are found in the Laurentian Channel, which borders the eastern end of the District.

OCEANOGRAPHY

The shelf break front is a sharp boundary between cool, less salty coastal water and warm, more saline slope water. Shelf break fronts occur in response to tides, winds, and fluctuating offshore currents. Currents from tides can form gyres that encircle the banks and may provide a "retention area" for larval fish. Tidal action also tends to produce a mixed water column on the banks. The water column on the shallower banks may be well mixed through much of the year, while the deeper banks have a stratified water column.

PLANTS

The plant life is primarily phytoplanktonic, but encrusting algae may occur on suitably hard substrates in some of the bank areas. The outer edge of the continental shelf has enhanced plant productivity because of the interaction of shelf and slope waters which brings nutrients to the surface.

ANIMALS

This District sustains a diverse fauna. The offshore banks are inhabited by many species of fish. Several species of large burrowing molluscs occur in the sandy substrate of offshore banks.

Lobster commonly move from the Inner Shelf to the Outer Shelf banks and continental slope and can occur along the Outer Shelf and upper slope from Browns Bank to southeast of Sable Island.

CULTURAL ENVIRONMENT

The Outer Shelf includes some of the most important fishing grounds for shellfish, especially scallops, and groundfish as a result of high production at the edge of the deep water. The area was heavily fished by many nations until Canada introduced the 200-mile fishing zone in 1977. Rock formations beneath the Outer Shelf and the Scotian Slope have provided most of the interest in the search for offshore hydrocarbons. Natural gas was discovered in the vicinity of Sable Island in the 1970s; the first wells to produce hydrocarbons (condensate) commercially in the early 1990s are located there. The seasonal concentration of whales, large pelagic fish, pelagic seabirds, and varied oceanic marine life offers great potential for adventure tourism. The area is traversed by several submarine cables, and two munitions dumping areas are identified on marine charts.

Associated Topics
T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T12.3 Geology and Resources, T12.11 Animals and Resources.

Associated Habitats
H1 Offshore.

931 OUTER SHELF BANKS

The Outer Shelf Banks include:

- 931a East Georges Bank
- 931b Browns/Baccaro Banks
- 931c LaHave Bank
- 931d Emerald Bank
- 931e Sable Island Bank
- 931f Banquereau Bank

GEOLOGY AND SEABED MORPHOLOGY

The Outer Shelf Banks were initially bedrock features known as cuestas, typically formed in coastal-plain environments by erosion during early geological periods when they were not submerged. A modern example of a cuesta is Prince Edward Island. Their appearance has been transformed by deposition of glacial till, which has been reworked by the sea to form the present-day surfaces. The banks have moderate relief, generally between 100 and 150 m, and are thus comparable in range to the elevations found on the mainland today. For comparison, the elevations of the Cobequid Mountains in the Wentworth area of Cumberland County are between 200 and 300 m above the surrounding coastal lowland; and North Mountain, between the Annapolis Valley and Bay of Fundy, reaches elevations of about 200 m.

The sandy components of the sand and gravels that are found on the bank tops can be shaped by wave and current activity into a variety of seabed features, including sand ridges, sand waves, ripples, and megaripples. Significant sand-wave fields are found on the western and eastern bars of Sable Island, and megaripples, sand ridges, and ribbons occur on the west Sable Island Bank (sub-Unit 931e) and Middle Bank (sub-Unit 921e). Browns Bank (sub-Unit 931b) has sand waves with megaripples on their sides. Sand waves and megaripples also occur in parts of Georges Bank (sub-Unit 931a), and large tidal ridges are found on the bank tops. Sand ridges are the largest of the features and migrate over long periods of time. Various ridges on Sable Island Bank mark the "footprint" of Sable Island moving to the east.

Patches of gravel, shell beds, and even boulders occur. Many of the surface features change with each storm or tidal event, and many of the smaller features are erased during intervening periods.

The northern edges of Sable Island Bank and Banquereau (sub-Unit 931f) have many steep-sided hanging valleys formed by glacial meltwater running over their edges. These extend onto the bank under the cover of surface sediments and are called tunnel valleys. Sediments moving off the edge of the shelf in these areas contribute material which maintains The Gully, a major submarine canyon and a probable remnant of an early drainage system. Similar movements on the outer edges of the Outer Shelf Banks, particularly during low sea level, have led to the formation of distinctive submarine canyons.

SEDIMENTS

The surfaces of the Outer Shelf Banks shallower than about 110 m consist chiefly of sands and gravels in various combinations in a layer generally less than 15 m deep. In some areas (such as the top of Emerald Bank, sub-Unit 931d), gravel predominates, but Sable Island Bank is mostly covered in sand. Where gravel is found, it can form a protective pavement of rounded stones embedded in the bottom. The sand tends to be smooth, hard, and flat with a variety of surface bedforms. Both types of bottom are classified as Sable Island Sand and Gravel.

The margins of Outer Shelf Banks deeper than 110 m have sediments that are principally sand and contain small amounts of clay, silt, and frequently gravel. The surface may be flat and smooth to undulating and hummocky. Called Sambro Sand, these deposits cover the saddles adjacent to the Outer Shelf Banks in many cases.

OCEANOGRAPHY

Currents derived from tides can form gyres that encircle the banks and may provide a "retention area" for larvae. Tidal action tends to produce a mixed water column on banks. The water column on the shallower banks may be well mixed through much of the year, while the deeper banks have a stratified water column. It is in these areas that shelf-break mixing processes occur.

PLANTS

The biomass of phytoplankton, the productivity, and the seasonal pattern of the waters over the shelves are similar to those found between the banks. Thus

there is no greater food supply for other organisms here than over adjacent banks and saddles. The outer edges of the banks are an exception, as phytoplankton productivity is greater in the zone of interaction of shelf and slope waters.

ANIMALS

More plant material reaches the seabed on the banks than in the adjoining areas and, consequently, vertebrate and invertebrate animal populations, including groundfish which feed near the bottom, are more significant on the offshore banks than in adjoining areas.

Cod stocks from Banquereau and the Sable Island Bank migrate during the summer to the outer coast of Nova Scotia and northern Cape Breton. Some of the fish also go into the Gulf of St. Lawrence. Southern Scotian Shelf cod overwinter in deeper water around LaHave and Browns banks. Some of the cod move from deeper water to the shallower areas of the banks in summer. On Georges Bank, Atlantic Cod occur principally on the eastern portion.

Concentrations of Atlantic Halibut occur along the edges of Georges Bank, Sable Island Bank, and Banquereau, and Witch Flounder have localized areas of high abundance in the deep holes of Banquereau. Haddock aggregate around the offshore banks at the beginning of the year and move onto the banks to spawn as the water temperature rises. The sand and gravel bottom typical of the banks is suitable for haddock spawning. Pollock (Boston Bluefish) spawn on the northeastern parts of the Georges and Browns banks, at several locations on the Scotian Shelf, and on Jeffries Ledge in the Gulf of Maine and migrate as juveniles to inshore areas.

Plate 9: Region 900, Offshore/Continental Shelf. This is an oblique aerial view looking east from Sable Island Bank (sub-Unit 931e) towards Sable Island (District 890) showing a jack-up drilling platform in the foreground. A glaciated Tertiary seabed covered with reworked sand and gravel deposits lies 60 m below the water surface (see Figures 31 and 32). Photo: A. Wilson.

Eggs and larvae of cod, haddock, pollock, and Silver Hake are abundant on the Western and Sable Island banks; those of cod and pollock are found there during midwinter and early spring, and those of Silver Hake during midsummer.

Sea Scallop occurs on the Georges and Browns banks, particularly where the bottom consists of firm gravel, shells, and rock. Two large bivalve species—the Ocean Quahog, and Stimpson's Surf Clam—are found typically on most of the offshore banks, but they are locally abundant. The Ocean Quahog is the main species on Georges Bank and concentrations have been found on the Western and Sable Island banks. Stimpson's Surf Clam occurs on Banquereau.

Sandy areas that make up much of Sable Island Bank include organisms such as the sand dollar *Echinarachnius parma* and the amphipods *Unciola irrorata* and *Leptocheirus pinguis*. Sand dollars are extremely abundant in some locations. Areas of coarse substrate on the banks support the Horse Mussel, the brittlestar *Ophiopholis aculeata*, Sea Scallop, lobster, and Toad Crab. Whales occur in the offshore waters, and mass strandings of Atlantic Long-finned Pilot Whale have occurred on Sable Island. Humpback Whales are often associated with offshore banks, where they take advantage of spawning fish such as Capelin, herring, and Sand Lance, as well as larger zooplankton. The area of Browns Bank 60 km south of Cape Sable is visited by about 200 Northern Right Whales each year.

Common Terns, Herring Gulls, and Great Black-backed Gulls have colonies on Sable Island and use adjacent waters for feeding.

CULTURAL ENVIRONMENT

The fishing banks have been heavily used for ground (bottom) fishing with both trawl and line since the seventeenth century. In the period following the Second World War, there was a deadly increase in fishing by many nations under the international regulations of the ICNAF (International Commission on Northern Atlantic Fisheries). However, declining stocks resulted in the establishment of a 200-mile fishing zone in 1977. Cod stocks on Banquereau (sub-Unit 931f) have declined severely and cod fishing is now closed in most areas. Main products include scallops, offshore lobsters, and ocean clams. The Georges Bank scallop stock is the largest scallop resource in the world. Concentrations of Stimpson's Surf Clam on Banquereau formed the basis for a fishery in the late 1980s.

The banks are also being intensively explored for natural gas and oil with some trial production under way in the early 1990s (see Plate 9). Plans, which include production platforms and seabed pipelines to the Nova Scotia coast, require suitable economic conditions.

There is one recorded munitions dump site (on Emerald Bank, sub-Unit 931d), and the Unit is crossed by several submarine cables.

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Sites of Special Interest

- Sable Island Bank and Sable Island, Georges Bank scallop areas also produce quantities of tertiary fossils, shells of molluscs and crustaceans as well as remains of mammoths, mastodons, walruses and whales
- Sable Island is a distinctive feature of Sable Island Bank (see Region 890)

Associated Coastal District

890 Sandy Island.

Associated Topics

T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.3 Geology and Resources, T12.11 Animals and Resources.

Associated Habitats

H1 Offshore.

932 BANK EDGES, SADDLES, AND CHANNELS

GEOLOGY AND SEABED MORPHOLOGY

The banks of the Outer Shelf are bordered by intervening deeper-water areas which include saddles and channels, submarine canyons, and the continental slope. Saddles generally have gentle relief and are shallower than about 200 m, and channels are deep, broad lowland features occurring at the depths of basins on the Middle Shelf. Saddles occur between Sable Island Bank/Western Bank, Emerald Bank, and LaHave Bank. Northeast Channel separates the Browns and Georges banks, and Laurentian Channel separates Banquereau and the eastern Scotian Shelf from banks off the coast of Newfoundland.

Submarine canyons occur along the outer edges of the Outer Shelf and extend down the continental slope. These are narrow, deep, and steep-sided features and include The Gully, and the Verrill, Dawson, Bonnecamps, Logan, Shortland, and Haldimand canyons (see T3.5). The Gully is a submarine canyon that approaches the Colorado River's Grand Canyon in depth, extending from 100 m to more than a kilometre between Sable Island Bank and Banquereau (by comparison, the Cape Breton highlands are roughly 500 m high). The Gully probably originated as a drainage channel and later developed into a canyon. The river and submarine canyon system at the mouth of the Hudson River on the east coast of the United States is an analogous feature.

The Northeast Channel joins the Outer Shelf between the Browns and Georges banks with the basins of the Gulf of Maine at depths between 200 and 300 m. Megaripples occur on the northern and eastern flanks of Northeast Channel at depths of 100–150 m, and sand waves on the bottom of Northeast Channel at depths of 230–260 m are evidently caused by tidal currents. These are some of the deepest recorded sand waves on the continental shelf, caused by strong tidal currents in the Bay of Fundy and Gulf of Maine.

The Laurentian Channel is the most impressive of these features, arising as a former river valley deepened by glacial ice, and having a sill (a shallower portion near the outer edge). This channel extends 700 km from the junction of the Saguenay and St. Lawrence rivers in Quebec to the edge of the continental shelf between Nova Scotia and Newfoundland and was cut 300 m below the rest of the shelf by the advancing ice. Down the slope from the Laurentian Channel is the Laurentian Fan, a delta-like feature containing sediments from the ancestral St. Lawrence River and from recent sediment flows.

At the edge of the Scotian Shelf, the bottom plunges downward to the continental slope. The shelf edge is marked by submarine canyons and glacial features which demonstrate the furthest extent of the ice sheets.

SEDIMENTS

Saddles between Outer Shelf Banks (Unit 931), parts of Northeast Channel, and The Gully generally have a cover of sand containing clay and silt, and frequently gravel (Sambro Sand and Gravel; see above and T3.5). The outer and inner ends of Northeast Channel also have a cover of glacial till, consisting of mixtures of significant amounts of silt and clay in addition to sand, gravel, and boulders. The glacial till is classed as Scotian Shelf Drift.

The bottom in the Laurentian Channel consists of glacial sediments, mainly clay, but silt has been exposed in some places. Flows of sediment down the slope from the channel can leave coarse deposits.

OCEANOGRAPHY

Saddles occur at depths of less than 200 m and form an entrance to the basins of the Middle Shelf (District 920) for subsurface water masses, typically the warmer, deeper slope water from the shelf edge. The Northeast Channel between the Browns and Georges banks, at depths of more than 200 m, is profoundly influenced by tides in the area, and significant currents occur. The deep Laurentian Channel permits incursions of deep water from the Atlantic into the Gulf of St. Lawrence.

PLANTS

The biomass of phytoplankton, the productivity of the waters in saddles, channels, and canyons, and seasonal patterns are similar to those of the adjacent shelves. The outer margin of the continental shelf, however, has greater plant productivity because of the interaction of shelf and slope water masses in a "frontal zone" whose position changes from year to

year. The elevated productivity is used by, and is believed to enhance, populations of fish and other organisms in the area.

The edge of the Outer Shelf is exposed periodically to water masses derived from the Gulf Stream, which flows to the south. Occasionally masses of the seaweed *Sargassum* can be found floating in the area.

ANIMALS

Witch Flounder is associated with deep holes and channels between the coastal banks, along the deep edges of the banks where water temperatures are suitable, and in gullies where bottom is usually clay, muddy sand, or mud. This species has localized areas of high abundance along the edge of the Laurentian Channel, between Sable Island and Banquereau, and in deep holes of Banquereau. Notable concentrations of Atlantic Halibut occur along the edges of the Georges and Sable Island banks and Banquereau. Various flatfish species occur in areas bordering the banks. Owing to the warmer water there, the outer margin of the shelf is a principal area of concentration for Silver Hake, which move onto the Scotian Shelf as temperatures rise in summer. The main known overwintering area for Atlantic Mackerel is the continental shelf south and southwest of Georges Bank.

Short-finned Squid are usually most common along the outer edge of the Scotian Shelf in June, usually between the Emerald and LaHave banks, and in some years along the entire edge of the shelf. They spread over the shelf later in the summer and later migrate southwest down the North American east coast. The young are brought back into the area by the Gulf Stream. Juveniles live in the Gulf Stream frontal zone and slope water off the edge of the continental shelf until they reach about 10 cm in length.

Deep-sea Red Crab is abundant along the shelf edge from the Fundian Channel to Sable Island at depths of 180–550 m. Significant quantities of lobster occur at the shelf edge from Browns Bank to Sable Island Bank.

One of the two best-known areas of concentration of the Northern Bottlenose Whale is in The Gully. Sperm Whales are usually found along the edge of the continental shelf or over canyons and deep basins between banks.

Seabird concentrations are greater in the shelf edge owing to the elevated productivity there. Wintering dovekies are most common over the edges of the Scotian Shelf. On Georges Bank, Wilson's Storm-petrel is most common over the shelf break.

CULTURAL ENVIRONMENT

Like Unit 931, the major marine activities on the shelf edge are fishing and oil and gas exploration. The Northeast Channel includes the area known as the "Hell Hole," where tuna is caught in notoriously difficult sea conditions. Harvestable concentrations of deep-sea Red Crab occur along the Scotian Shelf edge from the Fundian Channel to Sable Island. In the 1960s, whalers out of Blandford caught 67 Northern Bottlenose Whales.

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Sites of Special Interest

- The Gully—a deep canyon cut into the continental slope that is an ancient landscape feature and currently the habitat of the rare Northern Bottlenose Whale
- Montagnais structure—a circular structure in mesozoic rocks bounded by faults, just west of LaHave Bank (43.0°N 64.3°W), possibly a meteor impact site

Associated Topics

T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.7 Seabirds, T11.12 Marine Mammals, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.11 Animals and Resources.

Associated Habitats

H1 Offshore.

932 Bank Edges, Saddles, and Channels

940 SCOTIAN SLOPE

The Scotian Slope District is a very large area extending from the outer limit of the Outer Shelf (District 930), at approximately 200 m deep, to the political and resource management boundaries at depths of 4,000–5,000 m. This is a fully oceanic environment.

GEOLOGY AND SEABED MORPHOLOGY

The District includes the continental slope and rise, but as the boundary between them is not distinct, no attempt has been made to separate them as Units. The slope is indented by canyons and channels, including The Gully and the Laurentian Channel, both of which originate in District 930 (see Figure 32).

The area is underlain by thick post–Atlantic Rift sediments which accumulated continuously in the Scotian Basin since the Mesozoic. The Jurassic and Cretaceous rocks are mildly folded and faulted along the continental margin. Both the Shelburne sub-basin in the southwest and the Sable sub-basin in the northeast have extensive salt deposits. Late Tertiary and Quaternary deposits are horizontally bedded, and some outcrop in canyons and scarp features on the continental slope. The area is subject to high seismic activity with main stress in a southwest-northeast direction with earthquakes of up to magnitude 6.0. The Newfoundland earthquake of 1929 registered 7.2 on the Richter Scale.

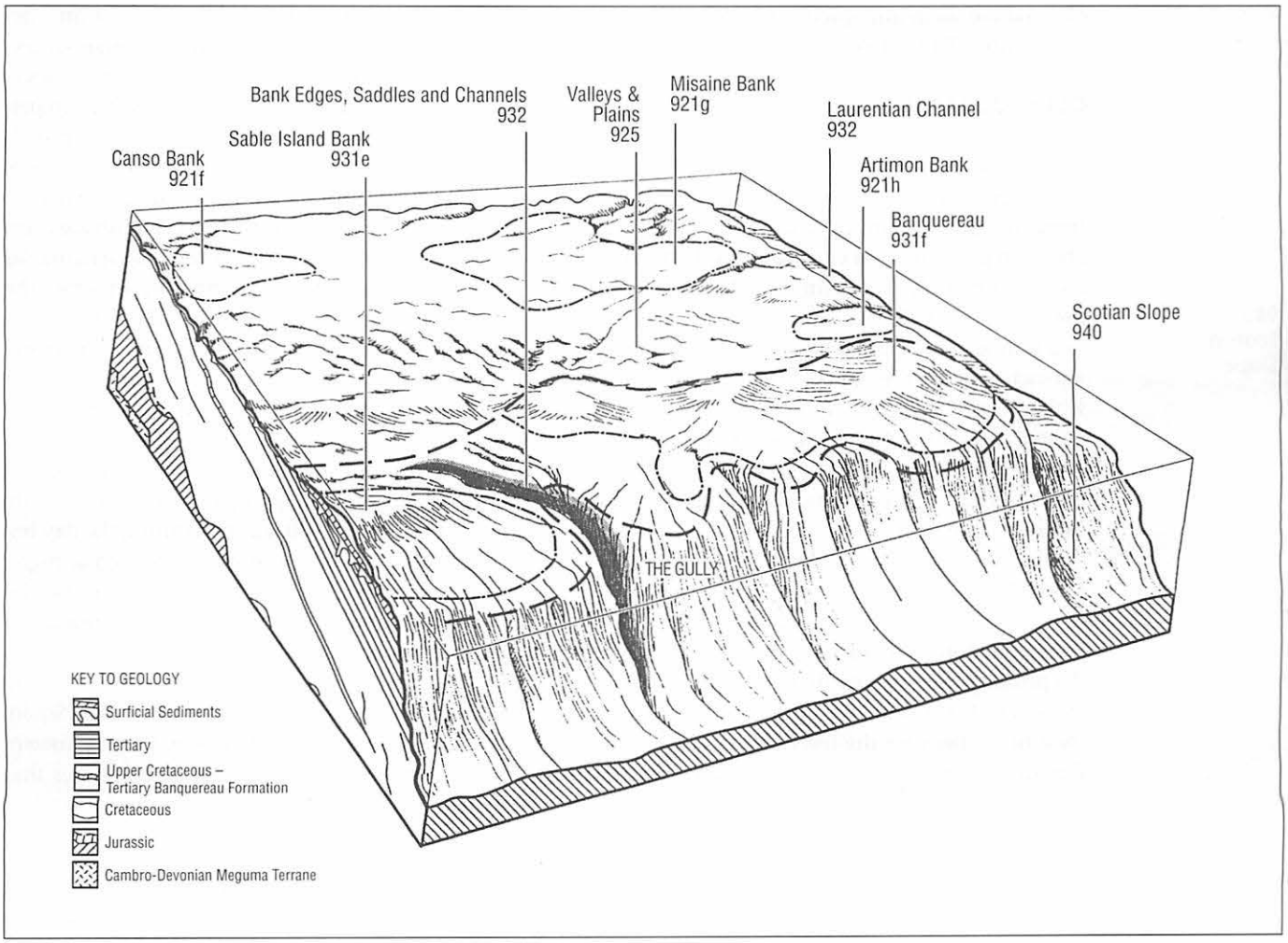

Figure 32: The Gully and Banquereau area of the Offshore/Continental Shelf (Region 900). The strong seabed features of the continental slope (District 940) and Laurentian Channel (Unit 932) can be seen.

SEDIMENTS

Recent sediments accumulating on the continental shelf are slumped along the shelf break and travel down the slope, often in the canyons, as turbidity currents. Thick accumulations of these slumped sediments are found on the slope between 200 and 2,000 m in depth. This talus material includes sand (Sable Island Sand and Gravel), marine silty clay (LaHave Clay), glaciomarine silty clay (Emerald Clay), and diamicton Till. The surfaces of these deposits are marked with pockmarks, paleo-iceberg scour marks, and sand ridges (Laurentian Fan). From the base of the slope towards the deep water is a gradation of surficial sediments: discontinuous, stratified mud series; muds alternating with silt and sand; and finally a sand sheet of Late Pleistocene or Holocene age. These deposits are cut by erosion channels of the same age. The deepwater sediments are covered with a thin layer of pelagic or hemipelagic sediment which includes fine mineral particles and the shells and spicules of marine organisms, for example, Radiolaria.

OCEANOGRAPHY

The District is oceanic in character. Surface waters are generally characterized as slope water derived from the Gulf Stream as warm-core rings diluted about 20 per cent with coastal water. In the area of the shelf break, this water mixes with coastal water of the continental shelf and, with mixing caused by tidally induced "shelf-break fronts," maintains nutrient-rich water at the surface. This effect diminishes with distance, so that nutrients are lower in the Gulf Stream and central Atlantic waters. Deep water at the foot of the slope is clear water derived from the Labrador Current moving along the bottom in a west-southwest direction.

PLANTS

Phytoplankton in the surface water is responsible for the primary productivity that occurs in the District. However, this is only significant in the area of the shelf break because the level of nutrients available diminishes rapidly towards deep water. Some floating patches of *Sargassum* weed occur; these are of relatively little ecological significance, even though they support a distinct community of animals and may rarely reach the Nova Scotia coast.

ANIMALS

The deepwater and oceanic conditions of District 940 support communities of animals not normally encountered in continental shelf waters. The two habitats of the Offshore, open-water and benthic, will be treated separately.

Open-water animals depend upon the primary productivity of the surface waters. Phytoplankton is grazed by herbivorous zooplankton—copepods, cladocerans, euphausiids, and a wide range of larval forms. There are also many carnivorous species, including crustaceans, medusae, and the larvae and juveniles of fish.

The nekton, or free-swimming animals, range in scale from jellyfish to whales, but the predominant forms are crustaceans, cephalopods, and fish. In the deep water these animals are grouped into vertically zoned communities: epipelagic (top), mesopelagic (middle), and bathypelagic (bottom). The mesopelagic community is characterized by a diurnal vertical migration—rising to the surface at night and descending to the depths at day. This migration of several hundred metres allows the deep-water species to take advantage of surface productivity. The epipelagic community includes surface-swimming molluscs (*Janthina* and *Argonauta*), cnidarians (*Valella* and *Physalia*), and fish (swordfish and flying fish). A number of species of invertebrates and fish are associated with *Sargassum* seaweed, and goose barnacles (*Lepas*) are associated with floating objects. The mesopelagic community is composed of crustaceans (shrimps and amphipods), cephalopods (squid and pelagic octopus and fish, particularly the distinctive Lanternfish, Viperfish, and Hatchetfish). These species are all predatory carnivores, are often darkly coloured, and may have reflective plates and photophores (light-producing organs). Lanternfish are found at a depth of 700–1,200 m during the day but rise to within 100 m of the surface to feed at night. The bathypelagic community lives in close association with the bottom and includes economically important types such as Grenadier that occur down to 2,500 m in depth. Many of the species that occur in the bathypelagic zone, such as the Giant Squid, which appears on a 30-year cycle, are poorly known.

The benthic habitat includes communities that live in or on the ocean bottom. In District 940 this is an environment without light. The generally soft sediments support an infauna of worms: Pogonophora and Polychaeta, cnidarians, sea pens, whip corals, solitary corals (*Flabellum*), a wide variety of scaphopod, pelecypod, and gastropod molluscs, and echinoderms. The crinoid (sea lily) *Rhizocrinus*

lofotensis has been found on the slope at a depth of 1,700 m. Epifauna includes any animal that roams around the sea bottom or attaches itself to a solid object. Old ice-rafted boulders are colonized by sponges, cnidarians, bryozoa, and brachiopods, while crustaceans, sea spiders, and brittle starfish are vagrants. A variety of bottom-feeding fish occur, including the Atlantic Batfish, Deep-sea Anglerfish, and chimaeras. Blue Hake occurs at a 1,300–2,500 m depth.

CULTURAL ENVIRONMENT

Though the deep water off Nova Scotia is distant from most common human experience, there are some cultural aspects of note. The open sea is fished for pelagic species such as swordfish and sharks which occur along the edges of the Gulf Stream. There is high potential for oil and gas development when technology, economic climate, and environmental considerations make this feasible. Deep water in The Gully has been voluntarily closed to tanker traffic by oil companies to protect the Northern Bottlenose Whale population. Many shipwrecks lie on the bottom, including some vessels that were intentionally disposed of. The freighter *Suerte*, which came ashore at Three Fathom Harbour, Halifax County, was towed out to be sunk off the continental slope in 1962. Munitions have been dumped south of Georges Bank in 2,000 m of water. The area is traversed by several submarine cables, some of which were damaged by the slumping of sediments caused by the Newfoundland earthquake. Cables recovered for repair or replacement are usually covered with growths of deep-sea animals. It is reasonable to presume that wrecks or any other objects of human origin that are placed on the bottom will become colonized by epibenthic animals.

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Associated Topics

T3.5 Offshore Bottom Characteristics, T6.1 Ocean Currents, T6.2 Oceanic Environments, T11.14 Marine Fishes, T11.17 Marine Invertebrates, T12.6 The Ocean and Resources.

Associated Habitats

H1.1 Offshore Open Water, H1.2 Offshore Benthic.